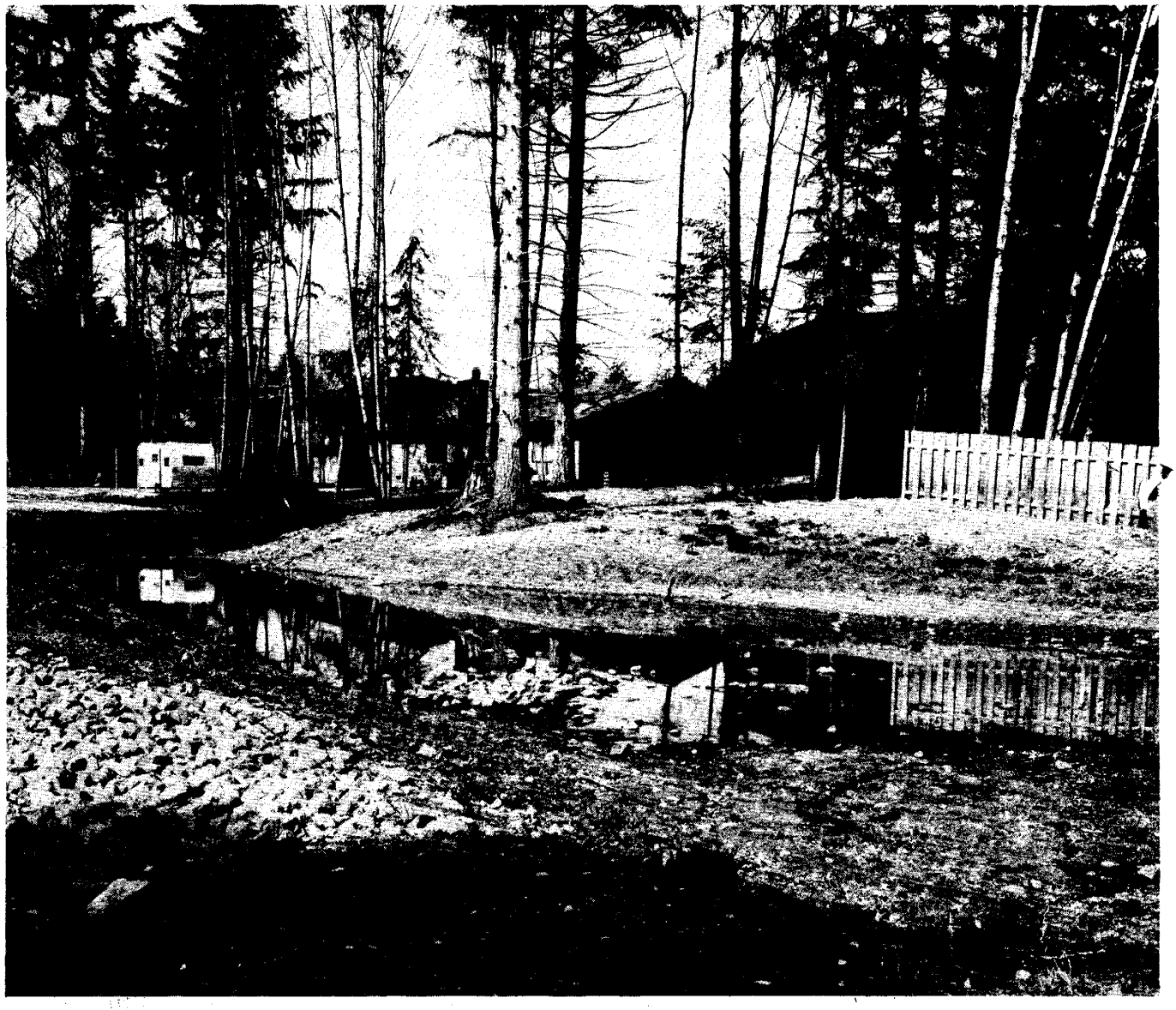
Curt Crawford 0008



Storm Drainage Control

Requirements and Guidelines

King County
Department of Public Works
Division of Hydraulics
May 1979

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FORWARD

Drainage plans are required as part of the application procedure for most development and use permits as specified in the King County Code (Ch. 20.50).

This manual is a professional technical guide prepared by King County staff with the assistance of a committee of consultants. This volume is an updated version of the one published in 1976. The manual is intended to assist those who prepare and submit applications by providing:

SECTION A - KING COUNTY CODE -- includes King County Code Chapter 20.50 which specifies basic county storm drainage requirements. Also included is Motion 2604 which expands on code requirements relating to short plats.

SECTION B - STORM DRAINAGE DESIGN -- includes methods, procedures, tables, graphs and other aids for design of the water transport system and for calculating volumes and release rates necessary to meet County detention requirements.

SECTION C - DRAINAGE POLICIES AND/OR RECOMMENDATIONS -- includes temporary erosion control methods and standards for various types of drainage systems. Some of these are required (policies). Those which are recommended have been found through experience to be generally most applicable to meeting King County requirements. It should be noted that these are not the only methods acceptable for use in the County, but any deviations from their use must be explained and justified.

Use of this Manual should assure that applicants meet King County drainage plan requirements and result in significant savings in both time and design costs.

Two other useful drainage control and management publications are also available:

1. STORM DRAINAGE CONTROL: STORM WATER MANAGEMENT PRACTICES -- A companion to this manual which provides a broad overview of engineering practices related to design for storm water control including alternative methods of runoff estimation, pond design and detention without ponds. (Available at Map Counter, King County Department of Public Works, 9th Floor, King County Administration Bldg.)

2. ON SITE SURFACE WATER MANAGEMENT -- this is a primer for developers which introduces King County's drainage regulations, procedures for submitting a drainage plan and a few sketches of management measures. (Available at Map Counter, Division of Bldg. & Land Dev., 4th Floor, King Co. Admin. Bldg.)

Questions relating to use of this Manual or the preparation and submission of drainage plans should be referred to the Department of Public Works, telephone 344-3874.

TABLE OF CONTENTS

PAGE NO.

Section A - King County Code Chapter 20.50 .... KCC-1 to 7

Section B - Storm Drainage Design

Introduction 1
Simple Retention/Detention Basin Design 5
Example Problems 7
Tables:
- Runoff Factors for Storm Sewers ..... Table 1 ... 18
- Retention/Detention Basin Equations .. Table 2 ... 19
- Maximum Cover for Concrete Pipe ..... Table 3 ... 20
- Corrugated Steel Pipe & Pipe Arch .... Table 4 ... 21
- Corrugated Steel Structural Pipe ..... Table 5 ... 22
- Corrugated Aluminum Pipe & Pipe Arch . Table 6 ... 23
- Infiltration Systems for Short Subdivision ..... Table 7 ... 24

Charts:
- Overland Flow Time (Average Velocities) ..... Chart 1 ... 25
- Nomograph for Computing Required Size of Circular Drain ..... Chart 2 ... 26
- Headwater Depth for Concrete Pipe Culverts with Inlet Control ..... Chart 3 ... 27
- Headwater Depth for C.M. Pipe Culverts with Inlet Control ..... Chart 4 ... 28
- Headwater Depth for C.M. Pipe Arch Culverts with Inlet Control ..... Chart 5 ... 29
- Hydraulic Elements vs. Depth of Flow . Chart 6 ... 30
- Drainage Ditches - Sections 1 & 2 .... Chart 7 ... 31
- Submerged Outlet for Concrete Pipe ... Chart 8 ... 33
- Submerged Outlet for CMP Culvert .... Chart 9 ... 34
- Submerged Outlet for Concrete Box Culverts ..... Chart 10 ... 35

Rainfall Intensity-Duration Curves:
- Mayfield ..... Chart 11 ... 36
- Renton/Seattle ..... Charts 12&13. 37
- Tacoma ..... Chart 14 ... 39
- Arlington, Concrete, Cosmos, Deming, Everett, Glacier, Gold Bar, Granite Falls, Hamilton, Lyman, Marblemount, Marysville, Morton, Mossy Rock, North Bend, Packwood, Snohomish, Snoqualmie, Stanwood, Sultan, Warnick, and Woodland ..... Chart 18 ... 40
- Skykomish ..... Chart 21 ... 41
- Cayuse, Chinook, Harts Stevens, and White Passes ..... Chart 31 ... 42
- Snoqualmie Pass ..... Chart 33 ... 43

TABLE OF CONTENTS (Continued)

		PAGE NO.
Nomograph for Flow in Triangular Channels	Chart 34	44
Capacity of Grate Inlet in Sump	Chart 35	45
Details:		
Restrictor/Oil Separator (Metal)	Figure 1	46
Temporary Erosion/Sedimentation Control Notes & Plan	Figure 2	47
Typical Detention Pond Outlet	Figure 3	48
Typical Pond Overflow Spillway	Figure 4	48
Typical Closed Detention Vault	Figure 5	49
Typical Closed Detention Pipe	Figure 6	50
Typical Parking Lot Ponding	Figure 7	51
Debris Barrier	Figure 8	52
Typical Channel Maintenance Road	Figure 9	53
Calculation Sheets (Example)		54

Section C - Drainage Policies and/or Recommendations. PR1-PR20

king county code~chapter 20.50

section a

king county code~chapter 20.50

section a

SURFACE WATER RUNOFF POLICY

Section:

20.50.010	Purposes.
20.50.020	Definitions.
20.50.030	Drainage plan - Submission.
20.50.040	Drainage plan - Contents.
20.50.050	Drainage plan - Mandatory requirements.
20.50.055	Drainage plan - Development in critical flood, drainage, and/or erosion areas.
20.50.060	Drainage plan - Review and approval.
20.50.070	Bonds and liability insurance required.
20.50.080	County assumption of maintenance.
20.50.090	Retroactivity in county maintenance of of subdivision facilities.
20.50.100	Applicability to governmental entities.
20.50.110	Effective date.
20.50.120	Severability.

20.50.010 PURPOSES. The council finds that this chapter is necessary in order to minimize water quality degradation by preventing the siltation of the county's creeks, streams, rivers, lakes and other water bodies; to protect property owners adjacent to developing land from increased runoff rates which could cause erosion of abutting property; to promote sound development policies which respect and preserve the county's watercourses; to insure the safety of county roads and rights-of-way; and to decrease surface water damage to public and private property. (Ord. 2281 §§ 1, 1975).

20.50.020 DEFINITIONS. (a) "Computations" means calculations, including coefficients and other pertinent data, made to determine the drainage plan with flow of rates of water given in cubic feet per second (cfs).

(b) "Department" means the Department of Public Works and Transportation.

(c) "Developmental coverage" means all developed surface areas within the subject property, including, but not limited to, rooftops, driveways, carports, accessory buildings and parking areas.

(d) "Director" means the director of the Department of Public Works and Transportation.

(e) "Drainage area" means the watershed (acreage) contributing surface water runoff to and including the subject property.

(f) "Drainage plan" means a plan for receiving, handling and transporting surface water within the subject property.

(g) "Peak discharge" means the maximum surface water runoff rate (cfs) determined for the design storm frequency.

(h) "Receiving bodies of water" means creeks, streams, rivers, lakes and other bodies of water into which surface waters are directed, either naturally or in manmade ditches or open systems.

(i) "Retention/detention facilities" means facilities designed either to hold runoff for a short period of time and then releasing it to the natural watercourse or to hold water for a considerable length of time and then consuming it by evaporation, plants or infiltration into the ground.

(j) "Subject property" means the tract of land which is the subject of the permit and/or approval action. (Ord. 2281 § 2, 1975).

20.50.030 DRAINAGE PLAN - SUBMISSION. (a) All persons applying for any of the following permits and/or approvals shall submit for approval a drainage plan with their application and/or request:

(1) Grading permit;
(2) substantial development permit;
(3) Flood control zone permit;
(4) Subdivision approval;
(5) Unclassified use permits;
(6) Conditional use permits;
(7) Building permits where the permit relates to five thousand or more square feet of development coverage within the property;
(8) Planned unit development.

(b) Drainage plans will be required for those short plat applications which present adverse drainage impacts as defined by administrative guidelines to be developed by the department and the Division of Building and Land Development and approved by the county council.

(c) The plan submitted during one permit/approval process may be subsequently submitted with further required applications. The plan shall be supplemented with additional information at the request of the department.

The plan requirement established in this section will not apply when the department determines that the proposed permit and/or activity:

(1) Will not seriously and adversely impact the water quality conditions of any affected receiving bodies of water; and/or

(2) Will not alter the drainage patterns, increase the peak discharge, and cause any other adverse effects in the drainage area. (Ord. 2812 § 3, 1975).

20.50.040 DRAINAGE PLAN - CONTENTS. All persons applying for any of the permits and/or approvals contained in Section 20.50.030 shall provide a drainage plan for surface water flows entering, flowing within, and leaving the subject property. The detailed form and contents of the drainage plan shall be described in procedures provided by the department and approved by the council. The procedures will set forth the manner of presenting the following required information:

(1) Background computations for sizing drainage facilities:

(A) Depiction of the drainage area on a topographical map, with acreage indicated;

(B) Indication of the peak discharge and amount of surface water currently entering and leaving the subject property;

(C) Indication of the peak discharge and amount of runoff which will be generated within the subject property if development is allowed to proceed;

(D) Determination of the peak discharge and amount of water that will be generated by the design storm frequencies as specified by the department at various points on the subject property.

(2) Proposed improvements for handling the computed runoff. (Ord. 2812 § 2, 1976: Ord. 2281 § 4, 1975).

20.50.050 DRAINAGE PLAN - MANDATORY REQUIREMENTS.

(a) Surface water entering the subject property shall be received at the naturally occurring location and surface water exiting the subject property shall be discharged at the natural location with adequate energy dissipators to minimize downstream damage and with no diversion at any of these points.

(b) The peak discharge from the subject property may not be increased due to the proposed development.

(c) Retention/detention facilities must be provided in order to handle all surface water in excess of the peak discharge.

(d) Where open ditch construction is used to handle drainage within the tract, a minimum of fifteen feet will be provided between any structures and the top of the bank of the defined channel.

(1) In open channel work, the water surface elevation will be indicated on the plan and profile drawings. The configuration of the finished grades constituting the banks of the open channel will also be shown on the drawings.

(2) Proposed cross-section of channel will be shown with stable side slopes. Side slopes will be 3:1 maximum unless paved or stabilized in some other manner approved by the department.

(3) The water surface elevation of the design flow will be indicated on the cross-section.

(e) Where a closed system is used to handle drainage within the tract, all structures will be a minimum of ten feet from the closed system.

Variances from any or all of the foregoing requirements may be permitted only after a determination by the department employing the following criteria:

(1) Capacity of downstream facilities;
(2) Acceptability of receiving bodies of water;
(3) Possibility of adverse effects of retention;
(4) Utility of regional retention facilities; and
(5) Capability of maintaining the system. (Ord. 2812 § 3, 1976: Ord. 2281 § 5, 1975).

20.50.055 DRAINAGE PLAN - DEVELOPMENT IN CRITICAL FLOOD, DRAINAGE, AND/OR EROSION AREAS. Development which would increase the volume of discharge from the subject property shall not be permitted in areas where existing flooding, drainage, and/or erosion conditions present an imminent likelihood of harm to the welfare and safety of the surrounding community, until such a time as the community hazard is alleviated. Where applications of the provisions of this section will deny all reasonable uses of the property, the restriction of development contained in this section may be waived for the subject property, provided that the resulting development shall be subject to all of the remaining terms and conditions of this chapter. (Ord. 2812 § 4, 1976).

20.50.060 DRAINAGE PLAN - REVIEW & APPROVAL. All storm drainage plans prepared in connection with any of the permits and/or approvals listed in Section 20.50.030 shall be submitted for review and approval to the department, Division of Hydraulics. (Ord. 2812 § 5, 1976: Ord. 2281 § 6, 1975).

20.50.070 BONDS & LIABILITY INSURANCE REQUIRED. The department is authorized to require all persons constructing retention/detention facilities to post with the director of

the department surety and cash bonds. Where such persons have previously posted, or are required to post, other such bonds with the director either on the facility itself or on other construction related to the facility, such person may, with the permission of the director and to the extent allowable by law, combine all such bonds into a single bond; provided, that at no time shall the amount thus bonded be less than the total amount which would have been required in the form of separate bonds, and provided further, that such a bond shall on its face clearly delineate those separate bonds which it is intended to replace.

(1) Construction Bond. Prior to commencing construction, the person constructing the facility shall post a construction bond in an amount sufficient to cover the cost of conforming said construction with the approved drainage plans. After determination by the department that all facilities are constructed in compliance with the approved plans, the construction bond shall be released.

(2) Maintenance Bond. After satisfactory completion of the facilities and release of the construction bond by the county, the person constructing the facility shall commence a one-year period of satisfactory maintenance of the facility. A cash bond to be used at the discretion of the director to correct deficiencies in said maintenance affecting public health, safety and welfare must be posted and maintained throughout the one-year maintenance period. The amount of the cash bond shall be determined by the director, but shall not be in excess of one thousand dollars. In addition, a surety bond or cash bond to cover the cost of defects or failures of the facilities shall also be posted and maintained throughout the one-year maintenance period.

(3) Liability Policy. The person constructing the facility shall maintain a liability policy in the amount of one hundred thousand dollars per individual, three hundred thousand dollars per occurrence and fifty thousand dollars property damage, which shall name King County as an additional insured, and which shall protect King County from any liability up to those amounts for any accident, negligence, failure of the facility, or any other liability whatsoever, relating to the construction or maintenance of the facility. Said liability policy shall be maintained for the duration of the facility by the owner of the facility; provided, that in the case of facilities assumed by King County for maintenance pursuant to Section 20.50.080, said liability policy shall be terminated when said county maintenance responsibility commences. (Ord. 2812 § 6, 1976: Ord. 2281 § 7, 1975).

20.50.080 COUNTY ASSUMPTION OF MAINTENANCE. King County is authorized to assume the maintenance of retention/detention facilities after the expiration of the one-year maintenance period in connection with the subdivision of land if:

(1) All of the requirements of Section 20.50.070 have been fully complied with.

(2) The facilities have been inspected and approved by the department after their first year of operation.

(3) The surety bond required in Section 20.50.070(2) has been extended for one year, covering the county's first year of maintenance.

(4) All necessary easements entitling the county to properly maintain the facility have been conveyed to the county. (Ord. 2812 § 7, 1976: Ord. 2281 § 8, 1975).

20.50.090 RETROACTIVITY IN COUNTY MAINTENANCE OF SUBDIVISION FACILITIES. If any person constructing retention/detention facilities and/or receiving approval of drainage plans prior to the effective date of the ordinance codified in this chapter reassesses the facilities and/or plans so constructed and/or approved and demonstrates, to the director's satisfaction, total compliance with the requirements of this chapter, the county may, after inspection, approval, and acknowledgement of the proper posting of the required bonds as specified in Section 20.50.080, assume maintenance of the facilities. (Ord. 2812 § 8, 1976: Ord. 2281 § 9, 1975).

20.50.100 APPLICABILITY TO GOVERNMENTAL ENTITIES. All municipal corporations and governmental entities shall be required to submit a drainage plan and comply with the terms of this chapter when developing and/or improving land including, but not limited to, road building and widening, within the unincorporated areas of King County. (Ord. 2812 § 9, 1976: Ord. 2281 § 10, 1975).

20.50.110 EFFECTIVE DATE. The effective date of the ordinance codified in this chapter shall be ten days after its enactment. The requirements of this chapter shall apply to all roads commencing construction and/or widening subsequent to December 31, 1975. Further, all plats receiving preliminary approval subsequent to the effective date of the ordinance codified in this chapter must comply with the terms of this chapter. In the case of all additional actions enumerated in Section 20.50.030, the terms of this chapter will apply where final action by the county has not been taken prior to the effective date of the ordinance codified in this chapter. (Ord. 2812 § 10, 1976: Ord. 2281 § 11, 1975).

20.50.120 SEVERABILITY. If any provision of this chapter or its application to any person or property is held invalid, the remainder of the chapter or the application of the provision to other persons or circumstances shall not be affected. (Ord. 2812 § 11, 1976: Ord. 2281 § 12, 1975).

MOTION NO. 2604

A MOTION establishing administrative guidelines for determining the need for drainage plans in conjunction with short plat applications in accordance with Ordinance No. 2281 and K.C.C. 20.50 as amended.

WHEREAS, Ordinance No. 2281 and K.C.C. 20.50 have been revised by the County Council, and

WHEREAS, the revised ordinance which has been adopted by the Council states that "Drainage plans will be required for those short plat applications which present adverse drainage impacts as defined by administrative guidelines to be developed by the Department and the Division of Building and Land Development and approved by the County Council," and

WHEREAS, the Department of Public Works and the Department of Planning and Community Development have developed guidelines delineating which short plat applications shall be required to include drainage plans for review by the Division of Hydraulics.

NOW THEREFORE, BE IT MOVED by the Council of King County:

1. Any short plat which meets one or more of the following criteria shall include a drainage plan which shall be submitted to the Division of Hydraulics for review and approval:

1) Two or more vacant or undeveloped lots are created where the average density is less than 35,000 square feet.

2) Natural drainage swales and/or natural retention areas are located within the short plat and exceed one foot in depth. These shall be identified by the applicant on the short plat.

3) The short plat lies within a designated critical area as defined by Ordinance No. 2281 as amended.

4) The short plat is located within or adjacent to the flood plain for a river or stream.

2. Drainage improvements for short plats shall comply with all applicable criteria set forth in K.C.C. 20.50.

3. If any provision of this motion is found to be inconsistent with the County's short plat ordinance (K.C.C. 19.26), revisions shall be made to insure consistency.

Motion No. 2604 was passed and approved July 26, 1976.

storm drainage design

section b

storm drainage design

section b

INTRODUCTION:

All storm waters originating on any proposed land development, roads, and all areas draining thereto shall be estimated as to rate of precipitation and to percentage of overland runoff in accordance with criteria hereinafter stated. Said estimates of precipitation and run-off shall be the basis of a drainage plan which shall be prepared by a Professional Civil Engineer and which shall be submitted to the King County Department of Public Works for review and approval. Said drainage plan shall incorporate, among other data, the best available topographical maps to clearly define: (1) the proposed development; (2) all areas, improved or unimproved, lying upstream and draining to and through the proposed development; and (3) drainage courses, natural or otherwise, to which the proposed development shall drain. Under no circumstances shall drainage be diverted in the proposed development to points of discharge other than those points receiving drainage prior to the proposed development.

Unless specifically approved otherwise by the Department of Public Works, the rate of storm water run-off from any proposed land development to any natural or manmade point of discharge downstream, such as storm sewers or ditches, shall not exceed the peak rate of runoff for the design storm occurring prior to the proposed land development, all in accordance with King County Code Chapter 20.50. In the event that waters from this development drain into a critical flood, drainage, and/or erosion problem area, the quantity of water from this site may be restricted to the existing quantity leaving this site prior to development. In the event that run-off from a proposed land development has in the past discharged directly into a relatively large body of water such as a lake or river or has or could discharge to such bodies of water via ditch or pipeline sized to accommodate anticipated increased run-off from the proposed land development, then it shall be the sole decision of the Department of Public Works to permit or not permit such increased run-off to said bodies of water from the proposed land development.

Restriction of storm water run-off from any proposed land development shall be effected by storm water holding facilities either open or closed or by introduction, on-site, of storm waters into permeable soils via an infiltration system.

The drainage plan shall incorporate all calculations for the determination of the required size of the systems. Said calculations shall be based on required criteria hereinafter stated and upon a rigid analysis of estimated run-off from areas contributing run-off to those facilities. Collection systems shall be either gravity pipe systems, open road ditches or open channels, or a combination of the three.

Open channels and gravity pipe systems across properties other than public right of way shall be treated in the drainage plan as if they were in public right of way. Construction plans shall be prepared for all storm water collection systems. Said plans shall include a plan-profile of the systems including cross sections of all open ditches and channels (profile may not be required when sufficient data is provided on the plans in a clear and concise manner). Said plans shall call out all hydraulic and physical data such as grades, bottom elevations of ditches and channels, inverts of pipes at all structures such as manholes and catch basins, size and length of all pipes, length of ditches and channels, top elevation of all catch basin covers. This includes the invert elevations of the existing or other proposed storm drainage system that the subject drainage plan proposes to tie into. Said plans shall be submitted to the Department of Public Works for review and approval. Required information to be shown on the plans and final plat such as easements, building set back lines, etc., are hereinafter specifically stated. Inspection and acceptance of the proposed storm drainage system will be done by King County in accordance with King County Code Chapter 20.50.

Run-off rates can be determined by the rational formula:

$$Q = C\ I\ A$$

Q = Run-off in cfs
C = Runoff coefficient
I = Rainfall intensity in inches per hour
A = Contributing area in acres

The run-off coefficient (C) should be based on Table 1. The rainfall intensity (I) will be based on the Rainfall Intensity-Duration Curves, prepared by the U. S. Weather Bureau for the area. The curve that is the closest to the plat will be used (see pages 36 to 43). Where other data of the same nature is used, the engineer should submit the curve along with the design analysis. For drainage areas less than 50 acres or producing a runoff of less than 20 cfs, a 10-year design frequency may be used. For areas greater than 50 acres or producing a run-off greater than 20 cfs, a 25-year design frequency will be used regardless of the size of the plat. The outlet flow may be further restricted if the downstream drainage basin is presently subject to serious flooding.

The time of concentration for rainfall should be computed for all ditches, channels, gutters, culverts and pipe systems. An initial collecting time of 10 minutes for unpaved areas and 5 minutes for paved areas may be taken at the most distant point of flow from a catch basin or culvert. From this point, the overland flow time to the nearest ditch, channel or gutter may be computed along with the flow time for the waterway using Chart 1, page 25, to estimate the velocity for each significantly different slope and overland flow condition. A common error is to combine areas with distinctly different flow patterns such as open, graded, forest and waterways. Once the runoff has reached a storm drainage system, the flow time through the open channel or pipe can be computed.

The following minimum roughness coefficients will be used:

n = 0.012 for concrete, clay or smooth interior metallic pipes

n = 0.024 for annular corrugated metal pipe

n = 0.024 will be used for hehical corrugated metal pipe unless the pipe is designed for outlet control or submerged outlet, then the following n values may be used.

PIPE DIAMETER	MANNING "n" (2-2/3" x 1/2") CORREGATIONS
12"	0.012
15"	0.012
18"	0.014
21"	0.016
24"	0.017
30"	0.018
36"	0.019
42"	0.020
48"	0.021

Storm drain pipe sizes may be selected by nomograph or calculated based on the Manning Formula. Culverts and pipes that are placed in ditches which will pass flows into the storm drainage systems may be designed from a booklet entitled Hydraulic Charts for the Selection of Highway Culverts, by the Bureau of Public Roads. Culverts should be designed to carry the design run-off with a headwater depth not greater than 2.0 times the culvert diameter for culverts 18 inches and under, or 1.5 times the culvert diameter for culverts greater than 18 inches (see pages 27-29). At all times the computed water surface must be at an elevation which will not saturate the base course under the paving.

PIPES FLOWING FULL:

PIPE SIZE	AREA	HCMP	CONCRETE PIPE
8"	0.349	$Q = 13.09\sqrt{Sl}$	$Q = 13.09\sqrt{Sl}$
10"	0.545	$Q = 23.72\sqrt{Sl}$	$Q = 23.72\sqrt{Sl}$
12"	0.785	$Q = 38.60\sqrt{Sl}$	$Q = 38.60\sqrt{Sl}$
15"	1.227	$Q = 69.97\sqrt{Sl}$	$Q = 69.97\sqrt{Sl}$
18"	1.77	$Q = 97.54\sqrt{Sl}$	$Q = 113.80\sqrt{Sl}$
24"	3.14	$Q = 173.00\sqrt{Sl}$	$Q = 245.08\sqrt{Sl}$
30"	4.91	$Q = 296.23\sqrt{Sl}$	$Q = 444.35\sqrt{Sl}$
36"	7.07	$Q = 456.51\sqrt{Sl}$	$Q = 722.57\sqrt{Sl}$
42"	9.62	$Q = 653.89\sqrt{Sl}$	$Q = 1089.81\sqrt{Sl}$
48"	12.57	$Q = 889.31\sqrt{Sl}$	$Q = 1556.29\sqrt{Sl}$
54"	15.90	$Q = 1161.49\sqrt{Sl}$	$Q = 2129.40\sqrt{Sl}$
60"	19.63	$Q = 1471.45\sqrt{Sl}$	$Q = 2820.28\sqrt{Sl}$
72"	28.27	$Q = 2294.00\sqrt{Sl}$	$Q = 4588.01\sqrt{Sl}$
18"X 11"	1.10	$Q = 58.32\sqrt{Sl}$	$Q = 58.32\sqrt{Sl}$
22"X 13"	1.59	$Q = 81.79\sqrt{Sl}$	$Q = 95.43\sqrt{Sl}$
25"X 16"	2.16	$Q = 107.61\sqrt{Sl}$	$Q = 143.48\sqrt{Sl}$
29"X 18"	2.83	$Q = 145.35\sqrt{Sl}$	$Q = 205.92\sqrt{Sl}$
36"X 22"	4.42	$Q = 248.73\sqrt{Sl}$	$Q = 373.09\sqrt{Sl}$
43"X 27"	6.36	$Q = 382.69\sqrt{Sl}$	$Q = 605.92\sqrt{Sl}$
50"X 31"	8.65	$Q = 547.69\sqrt{Sl}$	$Q = 912.82\sqrt{Sl}$

SIMPLE RETENTION/DETENTION BASIN DESIGN
(Yrjanainen & Warren Method)

By King County Code Chapter 20.50, the peak rate of run-off from an existing site shall not be increased due to the proposed development for a given design storm. Therefore, a retention/detention facility on-site may be required. There are a number of ways to design a retention/detention facility. However, for development of 200 acres or less the Yrjanainer & Warren Method which is described in the December, 1973, issue of the Water & Sewage Works may be used. For developments more than 200 acres in size, we recommend a more detailed method such as the Soil Conservation Service Method or the Colorado Urban Hydrograph Method. This method is discussed in the King County Stormwater Management Practices document which is available in the King County Department of Public Works.

The Yrjanainen & Warren Method for retention/detention basin design takes into consideration that the outflow is instantaneously changing as the head varies. This type of outlet can be analyzed by applying basic calculus to the controlling outflow equation. If the outflow is at a constant rate, i.e., a pump, the analysis is easier. The volume of storm water into the retention/detention basin can be determined by the rational formula. The required volume is the volume of run-off that flows into the basin minus that which flows out. Equations 1 and 2, shown below, relate the maximum required storage per acre imperviousness (V_S) to allowable outflow per acre imperviousness using the time for maximum storage (T) as a parameter and the type of outlet condition.

$$V_s = \frac{BT}{T + 25} - 40\ Q_oT$$ Orifice Outlet — Equation 1

$$V_s = \frac{BT}{T + 25} - 60\ Q_oT.$$ Constant Rate Outlet — Equation 2

B is a variable depending upon the slope of the Rainfall-Intensity-Duration Curve used and for the design storm.

$$B = i\ (T + 25)$$

T is defined as the instant storage begins until the peak is attained in minutes. This can be computed by taking the first time derivative of the storage volume (Vs) and setting it equal to zero. The resultant equations, relating T with Qo have been developed for conditions as tabulated in Table 2.

Qo is the maximum allowable outflow per acre imperviousness (Cfs/AC) using subject site only.

$$Q_o = \frac{\text{Allowable Outflow}}{\text{Acreage x Future Run-off Coef.}}$$

Allowable outflow is the total run-off in cfs leaving the site in the existing (predevelopment) condition and is usually computed by the rational method.

The total volume of water to be stored in the retention basin (V_T) may then be computed by the equation

$$V_T = V_S \times \text{acres} \times \text{developed run-off coefficient}$$

The assumptions in this method are that storm water rises in the retention/detention basin at a constant rate to fill the basin to the peak volume, and that the maximum allowable outflow is reached only at the peak volume.

A listing of the retention/detention equations for both a 10-year and 25-year frequency storm are shown in Table 2, page 19.

Table 2 lists only two outlet conditions, an orifice with head pressure and a constant flow (or pump) outlet. However, other types of outlets may be used since these equations are used only for calculating required storage volumes. For example, if a weir outlet is used, the "orifice with head" equations apply. The size/configuration of the outlet structure is calculated by relating the allowable outflow to the equations that define the outlet. Consideration for adequate maintenance must also be given to the selection of the outlet structure.

EXAMPLE PROBLEM

SIMPLE RETENTION/DETENTION BASIN DESIGN

Assume the example area is near Renton, Washington, (See page 8)

$$T_C = 10.0 + \frac{420 + 760}{1\ (60)} = 10.0 + 19.7 = 29.7$$

$C_{Future} = 0.40$ See Table 1, page 18 for 3.0-3.5 DV/GA

$C_{Existing} = 0.15$ Short Grass S=2%, See Table 1 page 18

$A_{1-8} = 15.8$ Acres

$I_{10\ Yr} = 0.83$ in/hr (Renton-Seattle Rainfall IDF Curve, pg. 37)

$$Q_{Existing} = CIA$$
$$= 0.15\ (0.83)\ (15.8)$$
$$= 1.97 \text{ cfs}$$

Since area < 50 acres and flow < 20 cfs use the 10-year frequency design storm

$Q_{Allowable} = 1.97$ cfs (See page 9)

Assume Retention/Detention Basin is located near CB No. 5.

$$Q_o = \frac{\text{Allowable Outflow}}{\text{Acreage x Future Runoff Coef.}}$$

$$= 1.97/15.8\ (0.4) = 0.311 \text{ cfs/Acre.C}$$

Assume orifice outlet condition exists. (See page 19)

$$T = -25 + \sqrt{1762/Q_o}$$

$$= -25 + \sqrt{1762/0.311} = 75.2 - 25 = 50.2 \text{ Min.}$$

$$V_S = \frac{2820T}{T + 25} - 40\ Q_oT$$

$$= \frac{2820\ (50.2)}{50.2 + 25} - 40\ (0.311)\ (50.2)$$

$$= 1{,}882 - 624 = 1{,}258 \text{ ft.}^3$$

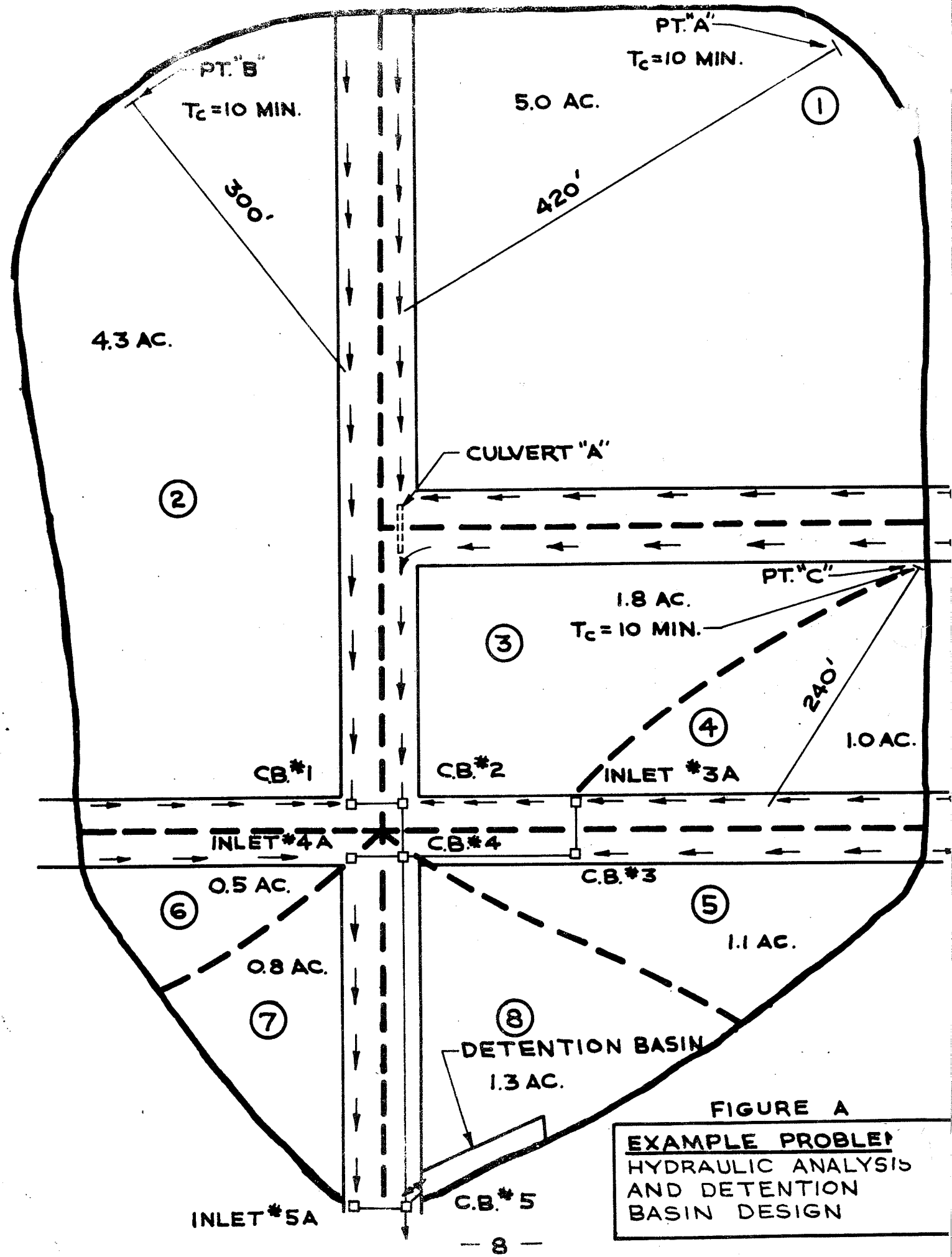


FIGURE A

EXAMPLE PROBLEM
HYDRAULIC ANALYSIS AND DETENTION BASIN DESIGN

EXAMPLE PROBLEM (Continued)

$V_{Total} = V_S \times \text{Acreage} \times \text{Run-Off Coefficient}$

$= 1{,}072\ (15.8)\ (0.40)$

$= 6{,}770\ \text{ft.}^3$

Assume the volume of runoff to be detained in an open basin with a design depth of 3 feet.

$$\text{Area of Detention basin} = \frac{6{,}770}{3} = 2{,}283\ \text{ft.}^2$$

Using a basin 20 feet wide

$L = 2283/20 = 114.2$ ft. (Say 114 ft.)

Required dimension of detention basin = 20' x 114' x 3'

Using the orifice formula, the outlet pipe can now be sized.

$C = 0.62$ (Sharp Edge Orifice)

$Q_{Allowable} = 0.62\ (a)\ \sqrt{2gh}$

$\left(\frac{Q}{0.62\,A}\right)^2 = H$

$2g$

h = Vertical distance between the headwater surface and the centroid of outflow area.

$$a = \frac{Q_{Allowed}}{0.62\sqrt{2gh}} = 1.97/0.62\ \sqrt{(2)\ (32.2)(3)}$$

$= 0.229\ \text{ft.}^2$

$$d = \sqrt{\frac{4a}{\pi}} = \sqrt{\frac{4(0.229)}{\pi}} = 0.539\ \text{ft.} = 6.47\ \text{inches}$$

Check capacity of 12" CMP:

Inlet Control Q 12" CMP = 5.1 cfs > 1.97 cfs OK

Flow Full @ Q 12" CMP = 2.7 cfs > 1.97 cfs OK

$S = 0.02$ ft/ft and $V = 3.5$ fps

Use 12" CMP outflow pipe with 6-1/2" hole in bottom plate at CB #5.

Also, an emergency overflow system must be included in the outlet facility located at least 6 inches above the overflow elevation. See figure 4.

EXAMPLE PROBLEM (Continued)
HYDRAULIC ANALYSIS OF INTERNAL DRAINAGE SYSTEM

Compute Flows, and Required Pipe Sizes for Areas Shown on page 8.

AREA I

Ground Cover - Short Grass-Slope of Ground = 2%

C = 0.4 A = 5.0 AC

Pt. "A" to Road Ditch 420 Ft. V = 1.0 ft/sec. (See pg. 25)

Road Ditch to Culvert "A" 165 Ft. V = 2.0 ft/sec. (See pg. 25)

$$\text{Time} = \frac{420}{(60)(1)} + \frac{165}{(60)(2)} + 10 = 7+1.4+10 = 18.4 \text{ Min.}$$

I = 1.15

Q = (.4)(5.0)(1.15) = 2.30 cfs

From Hydraulic Charts for the selection of Hyghway Culverts by Bureau of Public Roads:

12-inch Concrete for Q = 2.3 cfs

$\frac{HW}{D} = 0.95 > 2.0$ OK

12-inch CMP* for Q = 2.3 cfs

$\frac{HW}{D} = 1.1 < 2.0$ OK

Use 12-inch Concrete or CMP for Culvert "A"
*Annular CMP is used throughout example.

AREA 2

Groundcover - Short Grass-Slope of Ground = 2%

C = 0.4 A = 4.3 AC

Pt. "B" to Road Ditch 300 ft. V = 1.0 ft/sec. (See pg. 25)

Road Ditch to C.B. #1 350 ft. V = 2.0 ft/sec. (See pg. 25)

$$\text{Time} = \frac{300}{(60)(1)} + \frac{350}{(60)(2)} + 10 = 5+3+10 = 18 \text{ min.}$$

I = 1.15

Q = (.4)(4.3)(1.15) = 2.0 cfs

Use 12-inch Concrete or CMP (See Area 1)

C.B. #1 to C.B. #2 Slope = 1.0%

12-inch Concrete @ 0.08% = 3.8 cfs 2.0 cfs OK

Use 12-inch Concrete @ 1.0%

EXAMPLE PROBLEM (Continued)

AREA 3

C = 0.4 A = 1.8 AC

Length = Culvert "A" to CB #2 = 260'

$$\text{Time} = 18 \text{ min.} + \frac{260}{(60)(2)} = 18 + 2 = 20 \text{ min.}$$

I = 1.05

$$Q = \underset{\text{Area 3}}{(.4)(1.8)(1.05)} + \underset{\text{Area 1}}{(.4)(5.0)(1.05)} = (.4)(6.8)(1.05) = 2.9 \text{ cfs}$$

From Hydraulic Charts for the selection of Highway Culverts by Bureau of Public Roads:

12" Conc. for Q = 2.9 cfs 12" CMP for Q = 2.9 cfs

$\frac{HW}{D} = 1.1 < 2.0$ OK $\frac{HW}{D} = 1.3 < 2.0$ OK

Use 12" Conc. or CMP for entrance pipe @ CB #2

CB #2 to CB #4 Slope = 1.5%

$$Q = \underset{\text{Area 1 \& 3}}{(.4)(6.8)(1.05)} + \underset{\text{Area 2}}{(.4)(4.3)(1.05)} = (.4)(11.1)(1.05) = 4.7 \text{ cfs}$$

12" conc. @ 1.5% = 4.8 cfs > 4.7 cfs OK

12" CMP @ 1.5% = 2.6 cfs < 4.7 cfs Try 15" CMP

15" CMP @ 1.5% = 4.9 cfs > 4.7 cfs OK

Use 12" conc. or 15" CMP @1.5%

EXAMPLE PROBLEM (Continued)

AREA 4

Groundcover - Short Grass -Slope = 2%

C = 0.4 A = 1.0 AC

Pt. "C" to Road Ditch or Gutter 240' V = 1.0 ft/sec. (See pg. 25)

Road Ditch or Gutter to Inlet 3A 180' V = 2.0 ft/sec. (See pg. 25)

$$\text{Time} = \frac{240}{(60)(1)} + \frac{180}{(60)(2)} + 10 \approx 4+2+10 = 16 \text{ min.}$$

I = 1.25

Q = (.4) (1.0)(1.25) = 0.5 cfs

Inlet 3A to CB #3 Slope = 1.0%

8' conc. @ 1.0% = 1.2 cfs $>$ 0.5 cfs OK

Use 8" conc. @1.0%

AREA 5

C = 0.4 A = 1.1 AC

Time = 16 min. (Same as Area 4)

Q = (.4)(1.0+1.1)(1.25) = 1.1 cfs

CB #3 to CB #4 Slope = 1.0%

12" conc. @ 1.0% = 4.0 cfs $>$ 1.1 cfs OK

12" CMP @ 1.0% = 2.3 cfs $>$ 1.1 CFS OK

Use 12" conc. or CMP @ 1.0%

EXAMPLE PROBLEM (Continued)

AREA 6

C = 0.4 A = 0.5 AC

Inlet 4A to CB #4
By inspection, use 8" conc. or CMP

CB #4 to CB #5 C = 0.4 A = 13.7 AC

Time = 20 min. (See Area 3)

Q = (.4)(13.7)(1.05) = 5.8 cfs

12" conc. @ 1.0% = 4.0 cfs $<$ 5.8 cfs Try 15" conc.

15" conc. @ 1.0% = 7.0 cfs $>$ 5.8 cfs OK

15" CMP @ 1.0% = 4.2 cfs $<$ 5.8 cfs Try 18" CMP

18" CMP @ 1.0% = 6.6 cfs $>$ 5.8 cfs OK

Use 15" conc. or 18" CMP @ 1%

AREA 7

C = 0.4 A = 0.8 AC

Inlet 5A to CB #5
By inspection, use 8" conc. or CMP

AREA 8

C = 0.4 A = 1.3 AC

Length = 300' V = 5.5 ft/sec.

$$\text{Time} = 20 \text{ min.} + \frac{300}{(60)(5.5)} = 20 + 1 = 21 \text{ min.}$$

I = 1.01

Q = (0.4)(13.7+0.8+1.3)(1.01) = 6.4 cfs

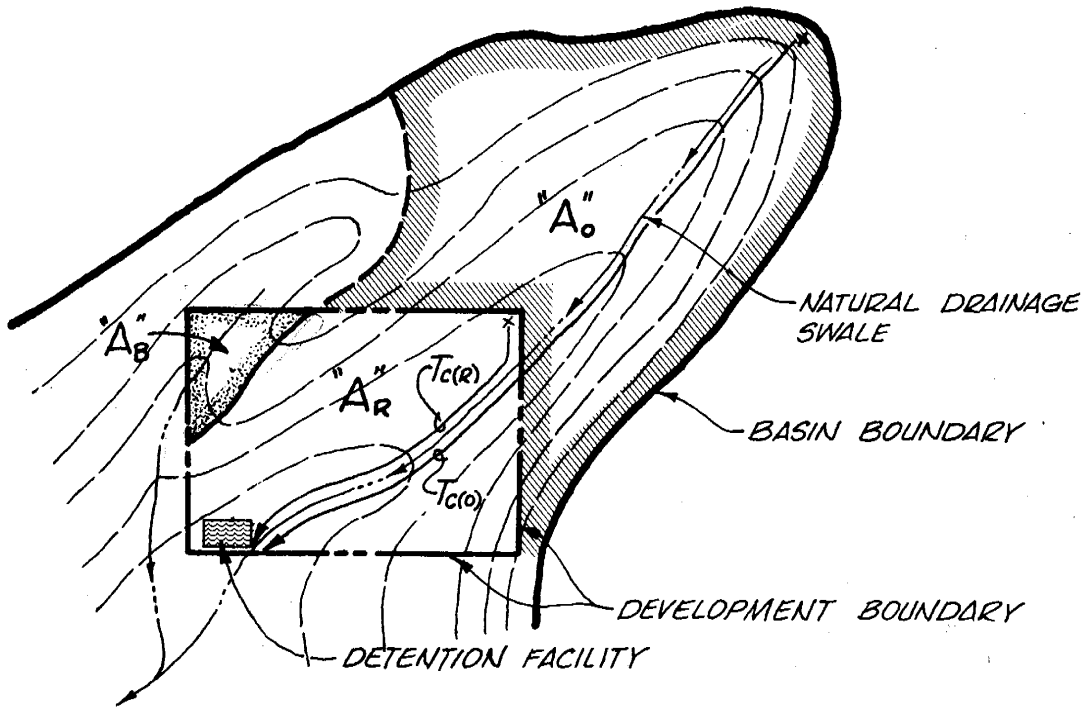
CB #5 to Detention Basin Slope = 1.0%

Use 18" CMP @ 1.0% (Simple Detention Basin Outlet Design)

Note the sample calculation sheet on page 54 covers the above analysis in a more condensed way.

Retention/detention facility design is often more complicated than the previous example because of variable field conditions and topography. The following two examples are meant to illustrate the Yrjanainen & Warren method as applied to commonly encountered conditions:

1. Determine required storage for a development that has off-site drainage entering it and on-site drainage bypassing the detention facility.



$A_B < 0.25\ A_R$

A_O = Area off-site contributing drainage to the development
A_R = Area of development with detained drainage
A_B = Area of development with drainage bypassing detention.

NOTE: It is assumed for this example that the area leaving the development unrestricted (A_B) is small relative to the total developed area and that it is within the same drainage basin and re-enters the natural drainage system within a reasonable distance downstream from the controlled outlet. Also, the downstream drainage system must be adequate to accept the increased peak runoff from the bypass area and a release of damages may be required.

Based on these assumptions, the size of the control outlet can be reduced accordingly to compensate for the restricted flow. Unless all of these assumptions are met, separate detention or retention would be required for area A_B.

(A) The detention volume is based only on the increased flow generated from the site after development:

$V_T = V_S A_R C_R$ (Future)

$Q_{Allowable}$ must be adjusted for bypassing drainage in order to increase required storage:

$Q_{Adjusted} = Q_{Existing(1)} - Q_{Bypass}$

Where $Q_{Existing\ (1)} = \left[A_R C_R \text{ (Exist)} + A_B C_B \text{ (Exist)}\right] i$;

and $Q_{Bypass} = A_B C_B$ (Future) i

Both Q's are for the same storm ("i" found from Tc(R))

$Q_o = Q_{Adjusted}/A_R C_R$ (Future)

The Standard Y & W method is then used with this Qo (and $V_T = V_S A_R C_R$) to complete the volume calculations.

(B) The required outlet size takes into account the off-site and on-site drainage and is then reduced to compensate for the bypassing area(s):

$Q_{Allowable} = Q_{Existing(2)} - Q_{Bypass}$

Where $Q_{Existing(2)} = \left[A_R C_R \text{ (Exist)} + A_B C_B \text{(Exist)} + A_o C_o \text{(Exist)}\right] i$

(This intensity ("i" is found from Tc(o))

and $Q_{Bypass} = A_B C_B$(Future) i ("i" found from Tc(R))

$Q_{Allowable}$ is then related to the outlet structure to determine the required size.

i.e. For an Orifice: $Q_{Allowable} = 0.62\ a\ \sqrt{2gh}$
For a weir: $Q_{Allowable} = CLH\text{-}3/2$
etc.

2. TO DETERMINE RETENTION/DETENTION FOR A PLAT THAT HAS NATURAL RETENTION ON IT (wetlands or pothole).

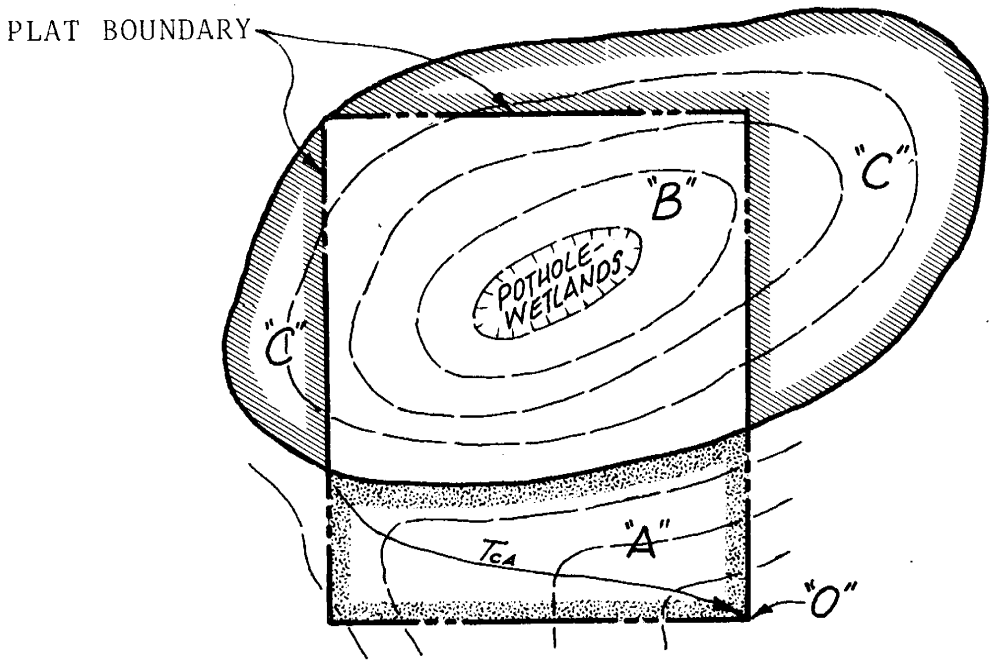
Assumptions:

A. Not in critical area where quantity needs to be restricted.

B. Where there is more than one (1) point of discharge, the direction of runoff from the depression must be at the normal overflow location.

C. The downstream drainage course must be analyzed to insure its capacity can satisfactorily handle this additional water.

D. The depression does not provide significant retention for the total drainage basin.



a. Determine Q_E (existing) at point "O", based on 10 or 25 year storm, dependent on standard criteria.

$$Q_E = AREA_A \times C_A \times i_A \qquad i_A = T_{CA}$$

b. 1. Where no off-site watershed drains to depression (Area "C" = 0) determine the volume of retention required using the Y & W method, using a 25 year storm.

$$AREA_T = AREA_A + AREA_B$$

$$C_T = \frac{C_A\ (AREA_A) + C_B\ (AREA_B)}{AREA_A + AREA_B}$$

$$Qo = Q_E/AREA_T\ (C_T$$

$$V_{TOTAL} = V_S\ (AREA_T)\ (C_T)$$

2. This simple method may be used with an off-site watershed area ("C") no greater than 10 acres.

$$AREA_T = AREA_A + AREA_B + AREA_C$$

$$C_T = \frac{C_A\ (AREA_A) + C_B\ (AREA_B) + C_C\ (AREA_C)}{AREA_A + AREA_B + AREA_C}$$

$$Q_o = Q_E/AREA_T\ (C_T)$$

$$V_{TOTAL} = V_S\ (AREA_T)\ (C_T)$$

NOTE: In those cases where the existing depression contains ponded water year round -- or in the case of a natural pond (with inlet and outlet) -- additional storage equal to any live storage displaced by filling will be required. Preservation of natural ponds and wetland areas is encouraged.

TABLE 1

RUNOFF FACTORS FOR STORM SEWERS

	FLAT 0-5%	ROLLING >5%
UNDEVELOPED LAND		
Wood & Forest	0.05	0.10
Sparse Trees & Ground Cover	0.10	0.15
Light Grass to Bare Ground	0.15	0.20
DEVELOPED AREA		
Pavement & Roofs	0.90	0.90
Gravel Roads & Parking Lots	0.75	0.80
City Business	0.85	0.90
Apartment Dwelling Areas	0.80	0.85
Industrial Areas (Heavy)	0.70	0.80
Industrial Areas (Light)	0.60	0.70
Earth Shoulder	0.50	0.50
Playground	0.25	0.30
Lawns, Meadows & Pastures	0.20	0.25
Parks & Cemetery	0.15	0.20

SINGLE FAMILY RESIDENTIAL
(Dwelling Unit/Gross Acre)

1.0-1.5 DU/GA	0.30
1.5-3.0 DU/GA	0.35
3.0-3.5 DU/GA	0.40
3.5-4.0 DU/GA	0.45
4.0-6.0 DU/GA	0.50
6.0-9.0 DU/GA	0.60
9.0-15.0 DU/GA	0.70

RETENTION/DETENTION BASIN EQUATIONS

AREA	TYPE OF OUTLET	10 YEAR DESIGN STORM		25 YEAR DESIGN STORM	
		PEAK STORAGE TIME (MINUTES)	MAXIMUM STORAGE VOLUME (FT^3/AC)	PEAK STORAGE TIME (MINUTES)	MAXIMUM STORAGE VOLUME (FT^3/AC)
RENTON-SEATTLE	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{1762}{Q_o}}$ 3 orifices $0.45(60)Q_o$	$V_s = \frac{2820\ T}{T+25} - 40\ Q_oT$ $0.45(60)Q_o$	$T=-25+\sqrt{\frac{2138}{Q_o}}$	$V_s = \frac{3420\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1175}{Q_o}}$	$V_s = \frac{2820\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{1425}{Q_o}}$	$V_s = \frac{3420\ T}{T+25} - 60\ Q_oT$
TACOMA	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{1875}{Q_o}}$	$V_s = \frac{3000\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{2194}{Q_o}}$	$V_s = \frac{3510\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1250}{Q_o}}$	$V_s = \frac{3000\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{1463}{Q_o}}$	$V_s = \frac{3510\ T}{T+25} - 60\ Q_oT$
NORTH BEND	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{2255}{Q_o}}$	$V_s = \frac{3607T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{2706}{Q_o}}$	$V_s = \frac{4329\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1503}{Q_o}}$	$V_s = \frac{3607\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{1804}{Q_o}}$	$V_s = \frac{4329\ T}{T+25} - 60\ Q_oT$
SNOQUALMIE PASS	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{4076}{Q_o}}$	$V_s = \frac{6522\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{5013}{Q_o}}$	$V_s = \frac{8020\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{2718}{Q_o}}$	$V_s = \frac{6522\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{3342}{Q_o}}$	$V_s = \frac{8020\ T}{T+25} - 60\ Q_oT$
SKYKOMISH	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{2603}{Q_o}}$	$V_s = \frac{4164\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{3075}{Q_o}}$	$V_s = \frac{4920\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1735}{Q_o}}$	$V_s = \frac{4164\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{2050}{Q_o}}$	$V_s = \frac{4920\ T}{T+25} - 60\ Q_oT$

TABLE 2

PIPE DIAMETER (INCHES)	MAXIMUM COVER (FEET) BY COMPACTION DESIGN									
	PLAIN		CLASS II		CLASS III		CLASS IV		CLASS V	
	DESIGN A	DESIGN C	DESIGN A	DESIGN C	DESIGN A	DESIGN C	DESIGN A	DESIGN C	DESIGN A	DESIGN C
12	18	57	10	32	14	43	21	65	26	82
18	18	52	11	33	14	44	22	67	28	85
24	16	50	11	33	15	45	22	69	28	86
30			11	33	15	45	23	69	29	87
36			11	33	15	45	23	69	29	88
48			12	30	15	41	23	63	29	80
60			12	28	16	38	24	59	30	74
72			12	27	16	37	24	56	30	70
84			12	27	16	33	24	53	30	67
96			12	27	16	33	24	53	30	67
108			12	25	16	33	24	52	30	67

CONCRETE PIPE

NOTE: 2' Min. Cover for Concrete or Metal Pipe for Primaries and Arterials. 1' Min Cover for Concrete or Metal Pipe for Residental Roads.

TABLE 3

*C = Circular, E = Elongated

PIPE DIAMETER (INCHES)	MIN. COVER (FEET)	MAXIMUM COVER (FEET) (Plate Thickness)									
		.064"		.079"		.109"		.138"		.168"	
		*C	E	C	E	C	E	C	E	C	E
12	2	77		84		108		113		118	
18	2	51		56		72		75		79	
24	2	38		42		54		56		59	
30	2	31		33		43		45		47	
36	2	25		28		36		37		39	
42	2	28		39		42	61	44	64	45	67
48	2	24		34		41	54	42	56	43	59
54	2			30		40	48	40	50	41	52
60	2					39	43	40	45	40	47
66	2					39		39	41	39	43
72	2							37		39	
78	2									36	
84	2									33	

CORRUGATED STEEL PIPE

2 2 3" x 1 2" Corrugations

SPAN-RISE (INCHES)	CORNER RADIUS (INCHES)	MINIMUM COVER	MINIMUM THICKNESS (INCHES)	MAXIMUM COVER (feet) FOR CORNER PRESSURE IN TONS PER SQ. FT.	
				2 TONS	3 TONS
18 x 11	3½	2(2**)	.064"	11	17
22 x 13	4	2(2)	.064"	11	16
25 x 16	4	3(2)	.064"	9	14
29 x 18	4½	3(2)	.064"	9	14
36 x 22	5	3(2)	.064"	7	12
43 x 27	5½	3(2)	.064"	5	11
50 x 31	6	3(2)	.079"	5	11
58 x 36	7	3(2)	.109"	5	11
65 x 40	8	3(2)	.109"	5	11
72 x 44	9	3(2)	.138"	5	11
79 x 49	10	3(2)	.168"	5	11
85 x 54	11	3(2)	.168"	5	11

CORRUGATED STEEL PIPE-ARCH

2 2/3" x 1/2" Corrugations

**Indicates minimum cover for 3ton/ft² corner pressure.

TABLE 4

*C = Circular, E = Elongated

PIPE DIAMETER (INCHES)	MINIMUM COVER (FEET)	MAXIMUM COVER (FEET)													
		12 GAGE		10 GAGE		8 GAGE		7 GAGE		5 GAGE		3 GAGE		1 GAGE	
		*C	E	C	E	C	E	C	E	C	E	C	E	C	E
60	2	38		57		75		86		100	103	109	122	119	133
72	2	32		47		62		68	71	73	86	79	101	85	111
84	2	27		41		53		57	61	60	74	63	87	67	95
96	2	24		35		46		50	53	53	64	55	76	57	83
108	2	21		31		41		46	47	48	57	50	67	51	74
120	2	19		28		37		43		45	51	46	61	47	66
132	2	17		26		34		39		43	47	44	55	45	60
144	2	16		23		31		35		42	43	42	50	43	55
156	2	14		22		28		33		39		41	47	42	51
168	2	13		20		26		30		37		41	43	41	--
180	2	12		19		25		28		34		40		40	--
192	2			17		23		26		32		38		40	41
204	3			16		22		25		30		35		39	
216	3			15		20		23		28		33		37	
228	3					19		22		27		32		35	
240	3					18		21		25		30		33	
252	3							20		24		29		31	

CORRUGATED STEEL STRUCTURAL PLATE PIPE

6'' x 2'' Corrugations

EQUIVALENT GAGE NUMBERS

GAGE NUMBER	THICKNESS (INCHES)	
	STEEL	ALUMINUM
16	.064	.060
14	.079	.075
12	.109	.105
10	.138	.135
8	.168	.164
7	.188	-
5	.218	-
3	.249	-
1	.280	-

TABLE 5

*C = Circular, E = Elongated

PIPE DIAMETER (INCHES)	MINIMUM COVER (FEET)	MAXIMUM COVER (FEET) (Plate Thickness)									
		.06"		.075"		.105"		.135"		.164"	
		*C	E	C	E	C	E	C	E	C	E
12	2	41		41		72		75		77	
18	2	27		27		48		50		51	
24	2	20		20		36		37		38	
30	2	16		16		28		30		31	
36	2	13		13		24		25		25	
42	2	18		23		39	41	40	43	40	44
48	2			20		36		38		39	
54	2					32		33		34	
60	2							30		31	
66	2							27		28	
72	2									26	

CORRUGATED ALUMINUM PIPE
2 2/3" x 1/2" Corrugations

SPAN-RISE (INCHES)	CORNER RADIUS (INCHES)	MINIMUM COVER (FEET)	MINIMUM THICKNESS (INCHES)	MAXIMUM COVER FOR CORNER PRESSURE IN TONS PER SQ. FT.	
				2 TONS	3 TONS
18 x 11	4	2(2**)	.06	13	20
22 x 13	4	2(2)	.06	11	16
25 x 16	4	2(2)	.06	9	14
29 x 18	4½	2(2)	.06	9	14
36 x 22	5	3(2)	.06	7	12
43 x 27	5½	3(2)	.075	5	11
50 x 31	6	3(2)	.105	5	11
58 x 36	7	3(2)	.135	5	11
65 x 40	8	3(2)	.135	5	11
72 x 44	9	3(2)	.164	5	11

CORRUGATED ALUMINUM PIPE ARCH
2 2/3" x 1/2" Corrugations

**Indicates minimum cover for 3 ton/ft corner pressure.

State of Washington
Highway Hydraulic Manual
C 8/1/72

TABLE 6

INFILTRATION SYSTEMS FOR SHORT SUBDIVISIONS
TABLE 7

PERC RATE (MIN/IN)	SIZE OF DRYWELL FT^2	PERC RATE (MIN/IN)	SIZE OF DRYWELL FT^2
Less than 1	112	9	972
2	216	10	1,080
3	324	11	1,188
4	432	12	1,296
5	540	13	1,404
6	648	14	1,512
7	756	15	1,620
8	864		

ASSUMPTIONS:

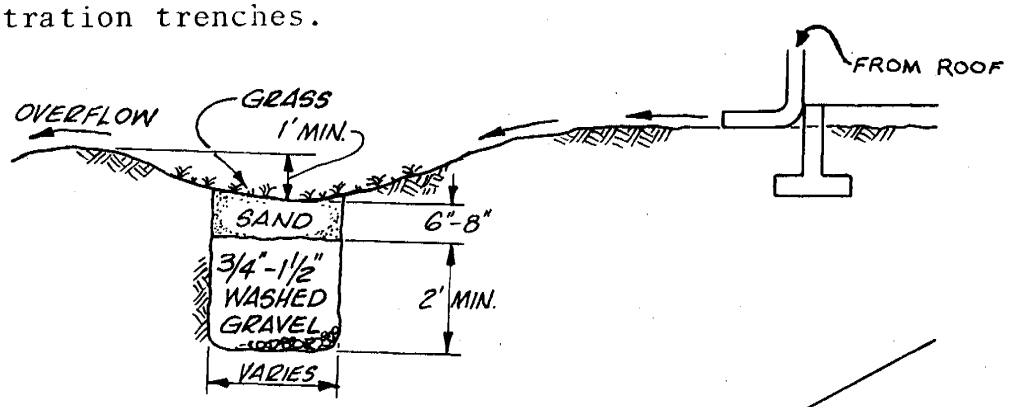
1. Q proposed is based on the construction of a 3,000 $ft.^2$ single floor house and garage. The drywell size will need to be computed for anything greater than 3,000 $ft.^2$.

2. Storm water infiltration systems are not permitted for percolation rates that exceed 15 min/in (i.e. 20 min/in is not permitted).

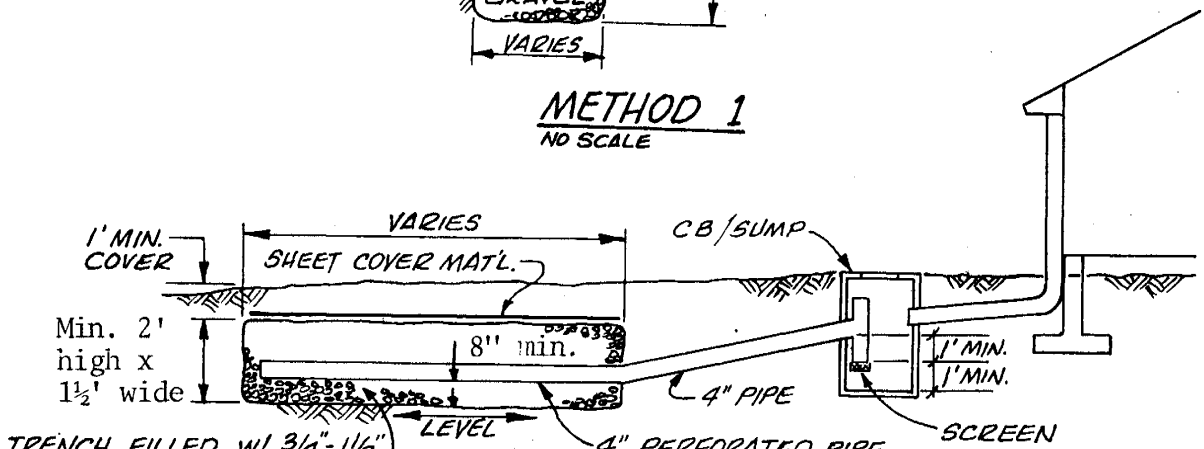
3. Infiltration systems must not be used by septic systems or where soil stability problems may be caused such as adjacent to steep slope areas, slide hazard areas, etc.

4. Ground water table must be at least 1 foot below the drywell bottom.

5. A minimum 10 foot wide spacing is required between infiltration trenches.



METHOD 1
NO SCALE



METHOD 2
NO SCALE

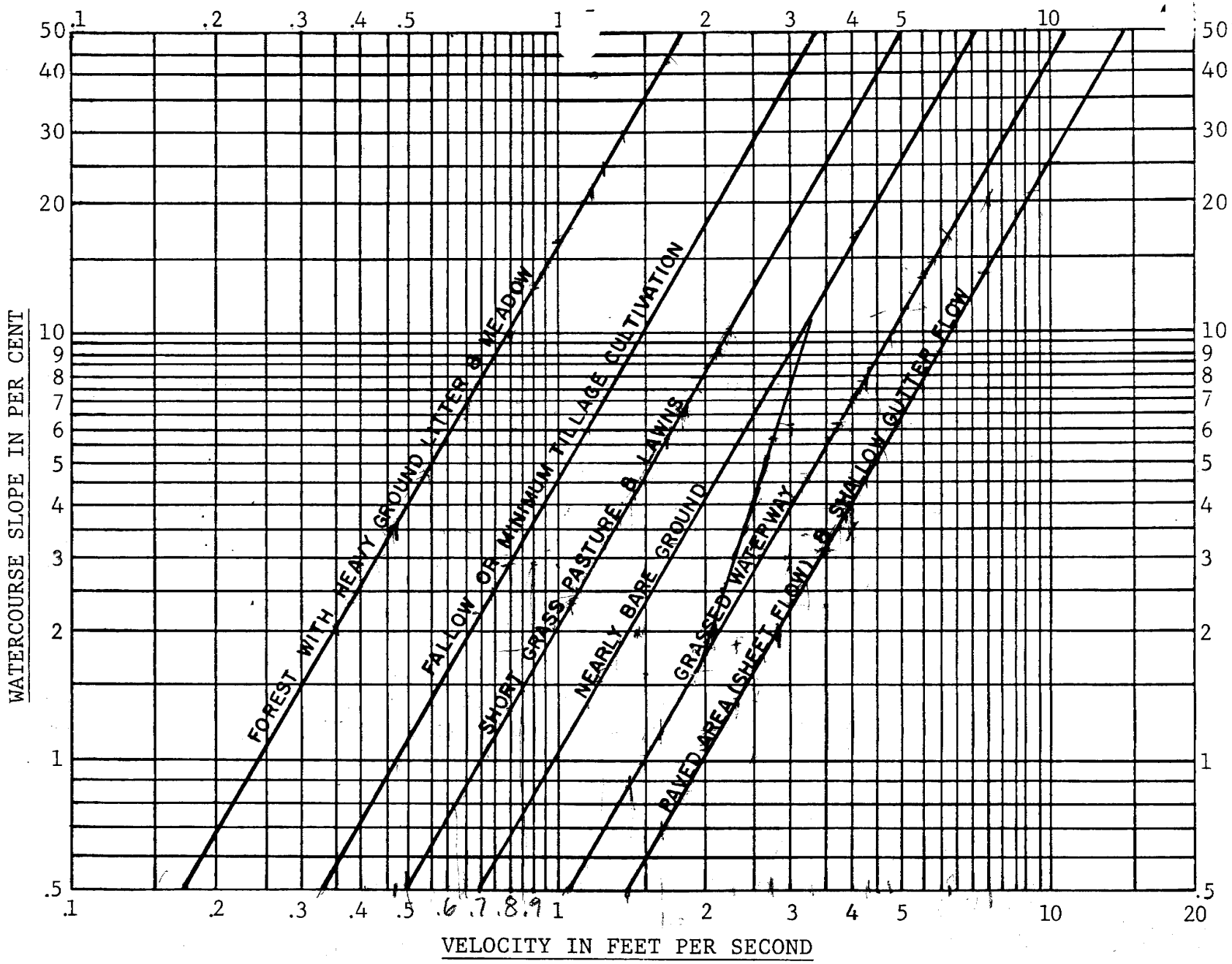
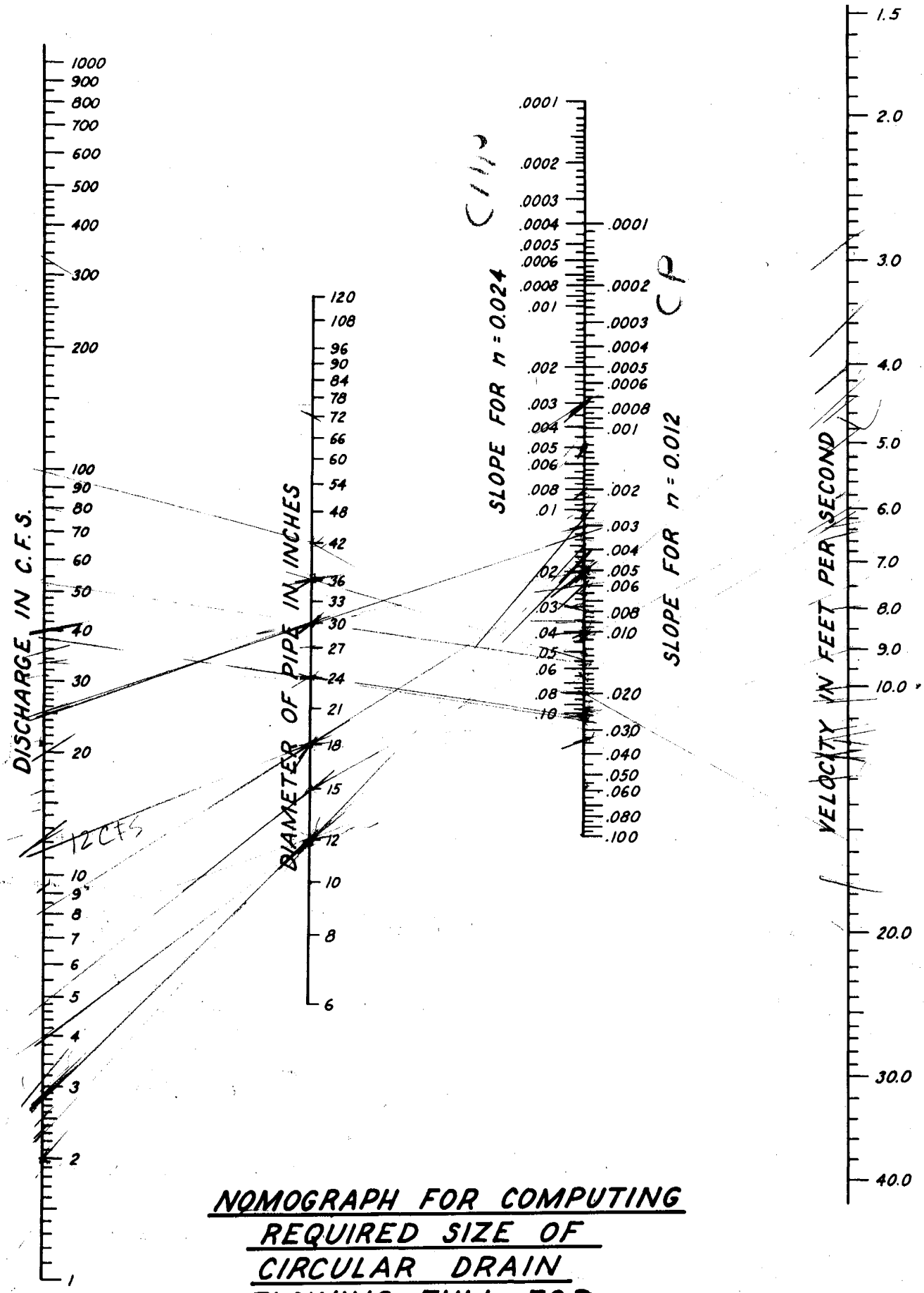


CHART 1

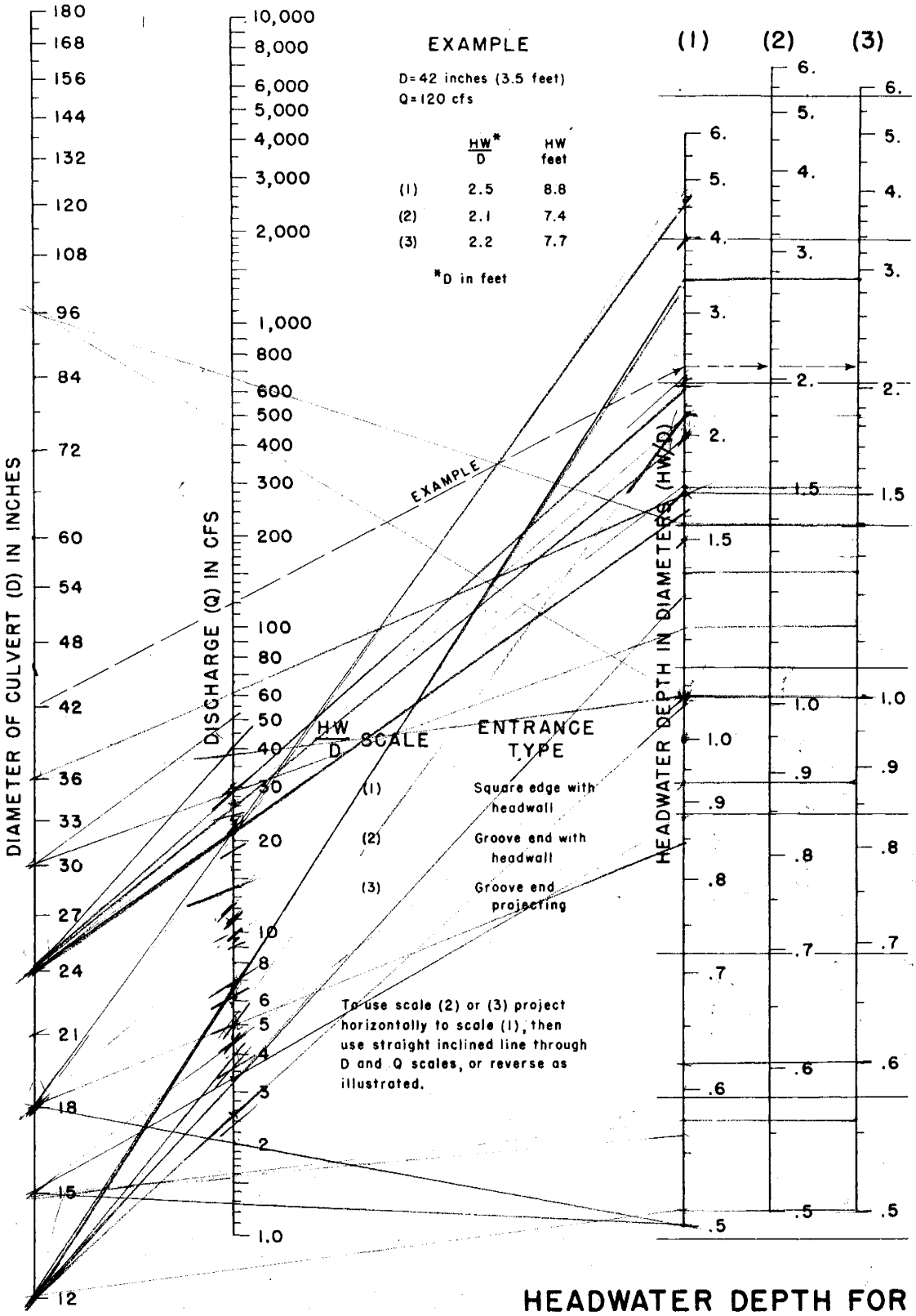
AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR OVERLAND FLOW

SOIL CONSERVATION SERVICE
TECHNICAL RELEASE NO. 55
JANUARY 1975



NOMOGRAPH FOR COMPUTING REQUIRED SIZE OF CIRCULAR DRAIN FLOWING FULL FOR n = 0.012 OR n = 0.024

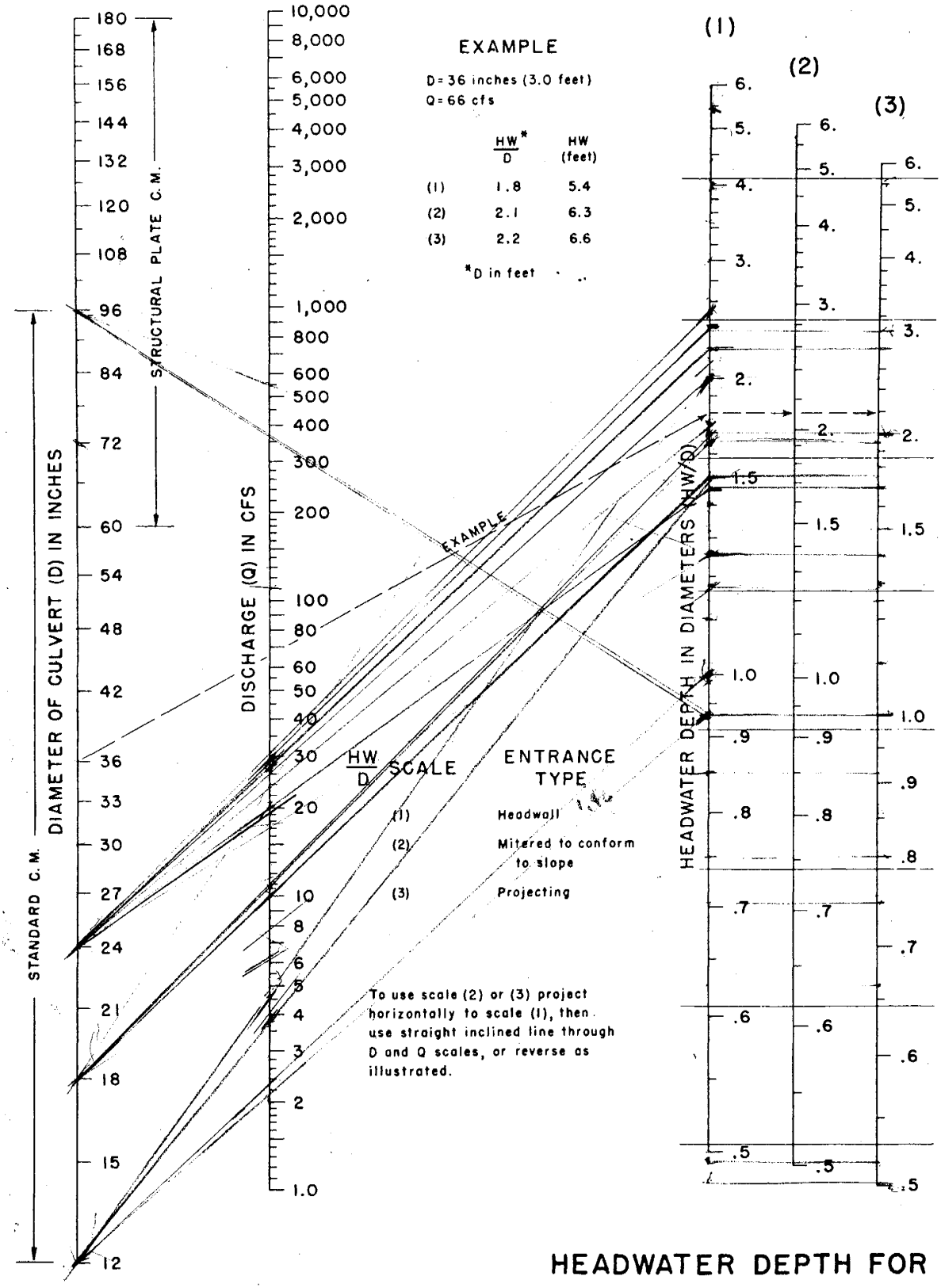
CHART 2



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

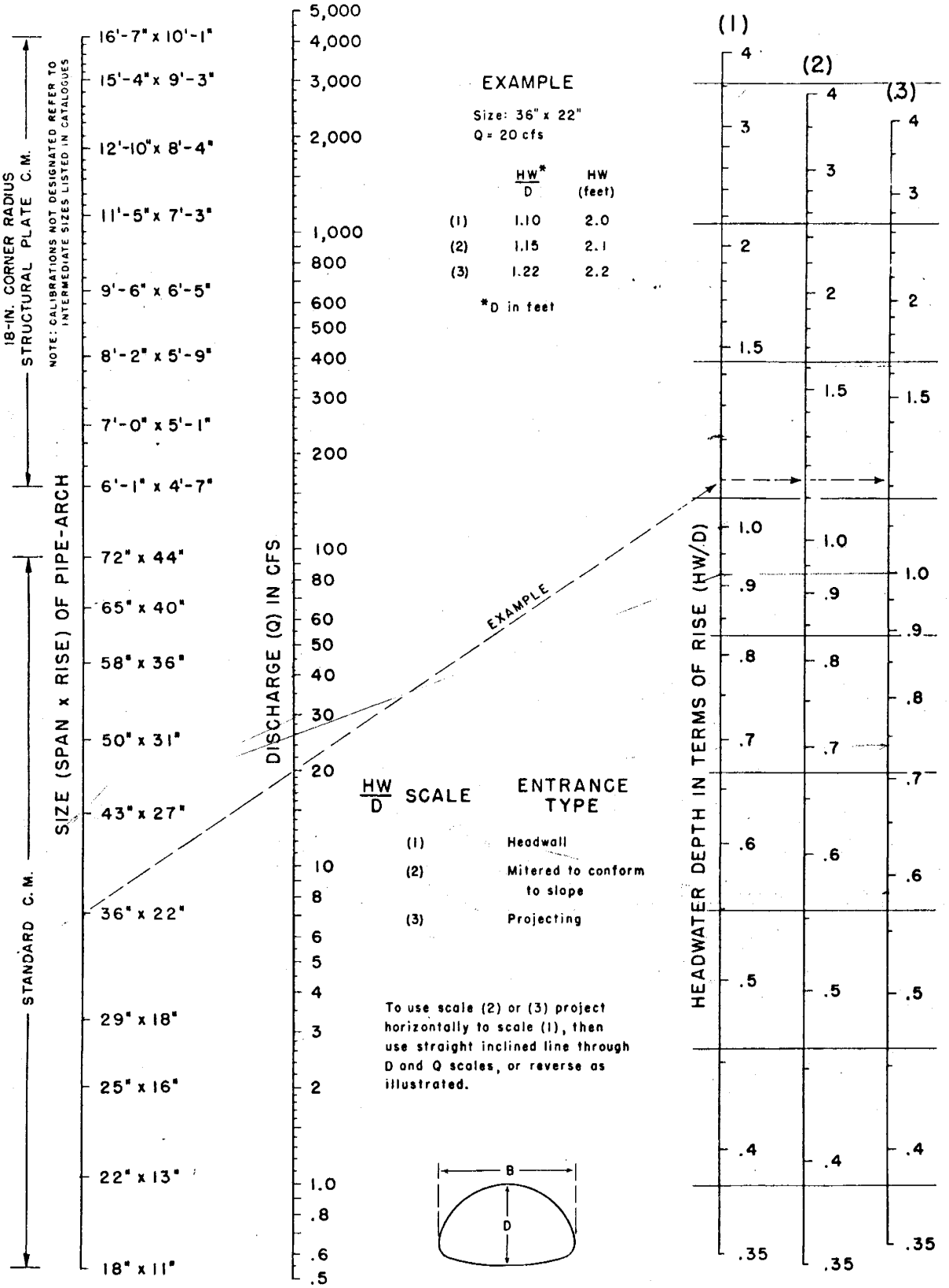
CHART 3



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 4



HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 5

ELEMENTS OF CIRCULAR SECTIONS

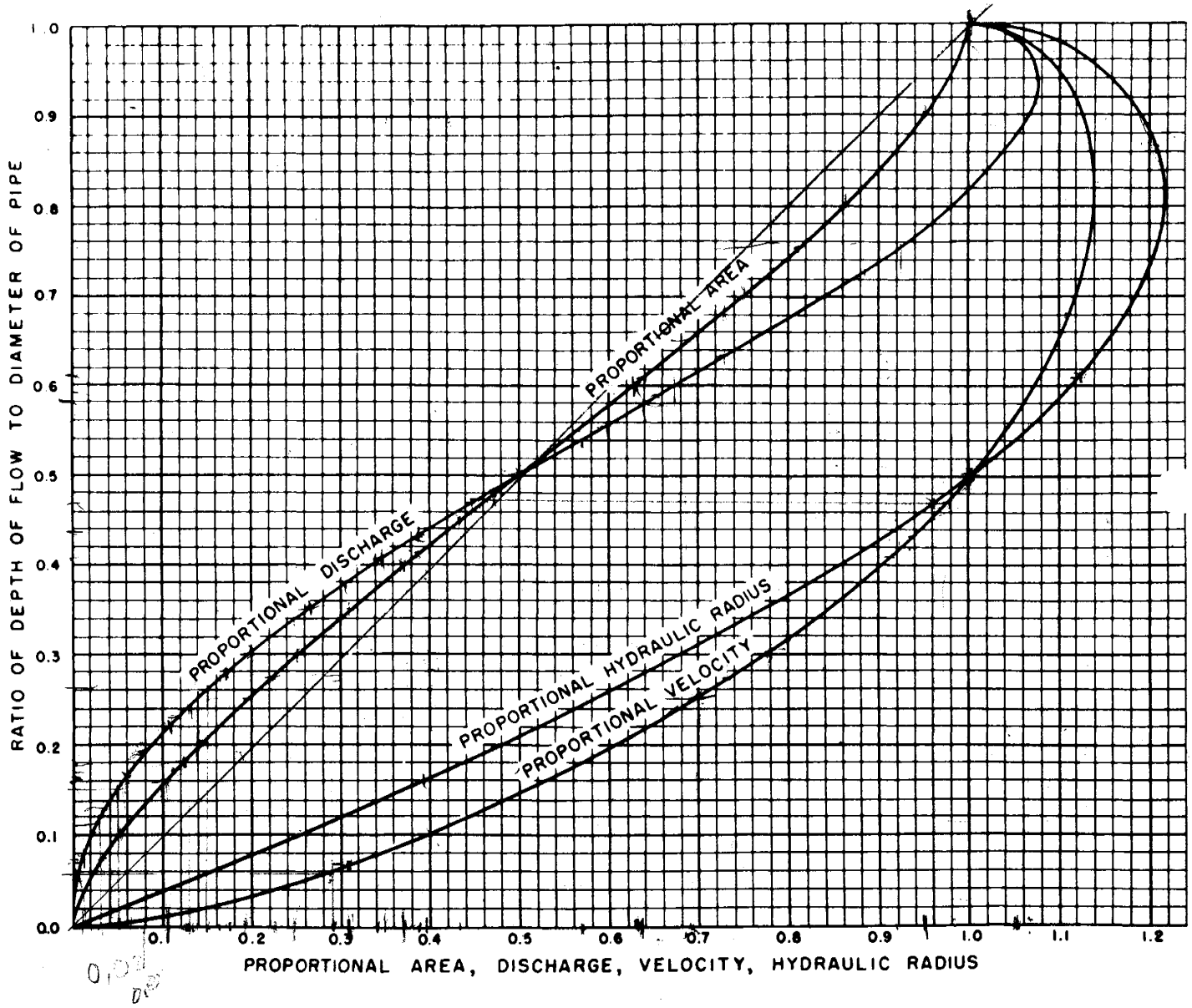
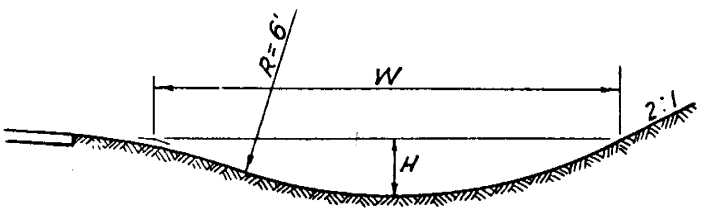
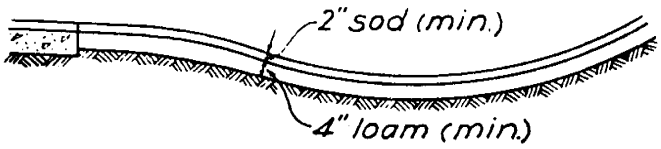


Chart 6

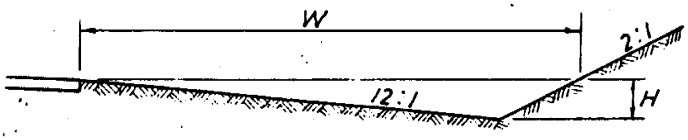
DRAINAGE - DITCHES - COMMON SECTIONS



D-1 SEGMENTAL

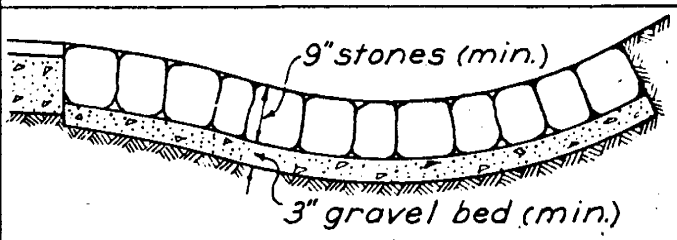


SODDED GUTTER

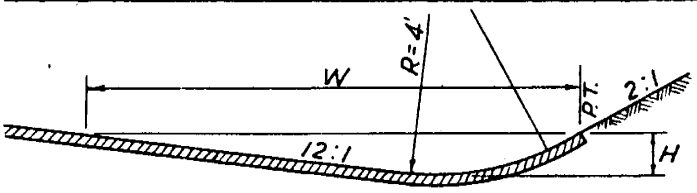


D-1A TRIANGULAR

Unequal side slopes



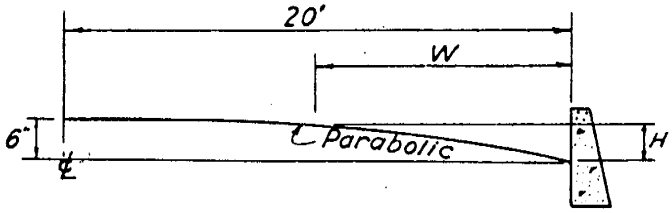
COBBLED GUTTER



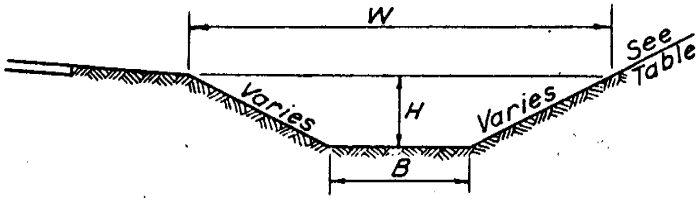
D-1B BITUMINOUS GUTTER

Base required same as for concrete pavement.

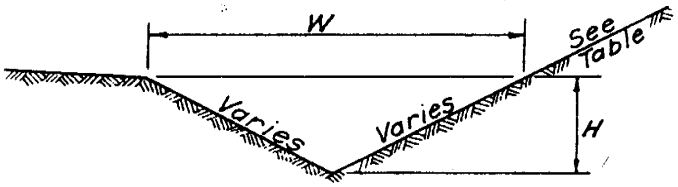
CONCRETE GUTTER



D-1C CURBED CROWNED STREET



D-2, D-3, D-4, D-5 TRAPEZOIDAL



D-6, D-7, D-8, D-9, D-10, D-11

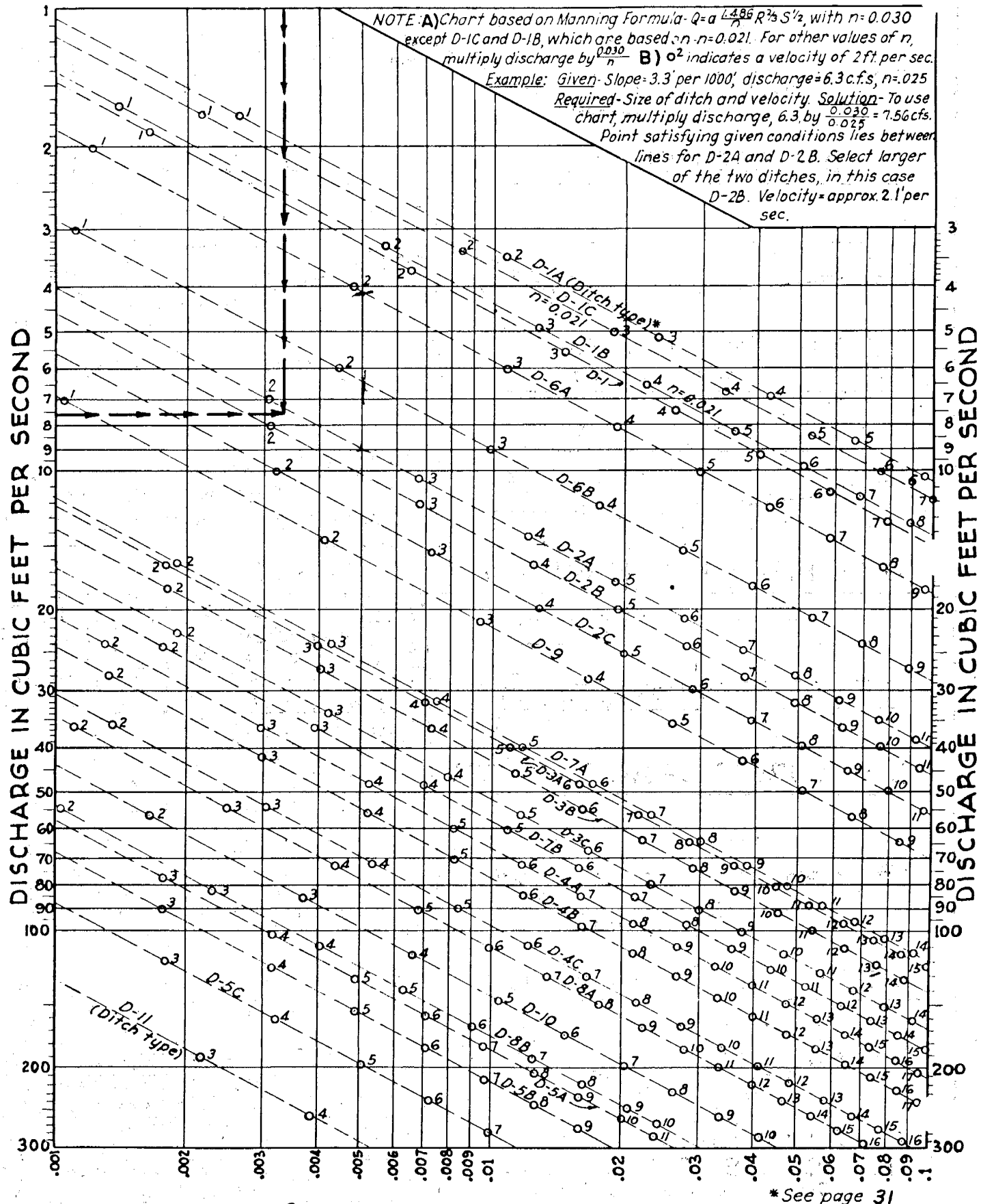
ISOSCELES TRIANGULAR

D-9, D-10 and D-11 - Airport ditches

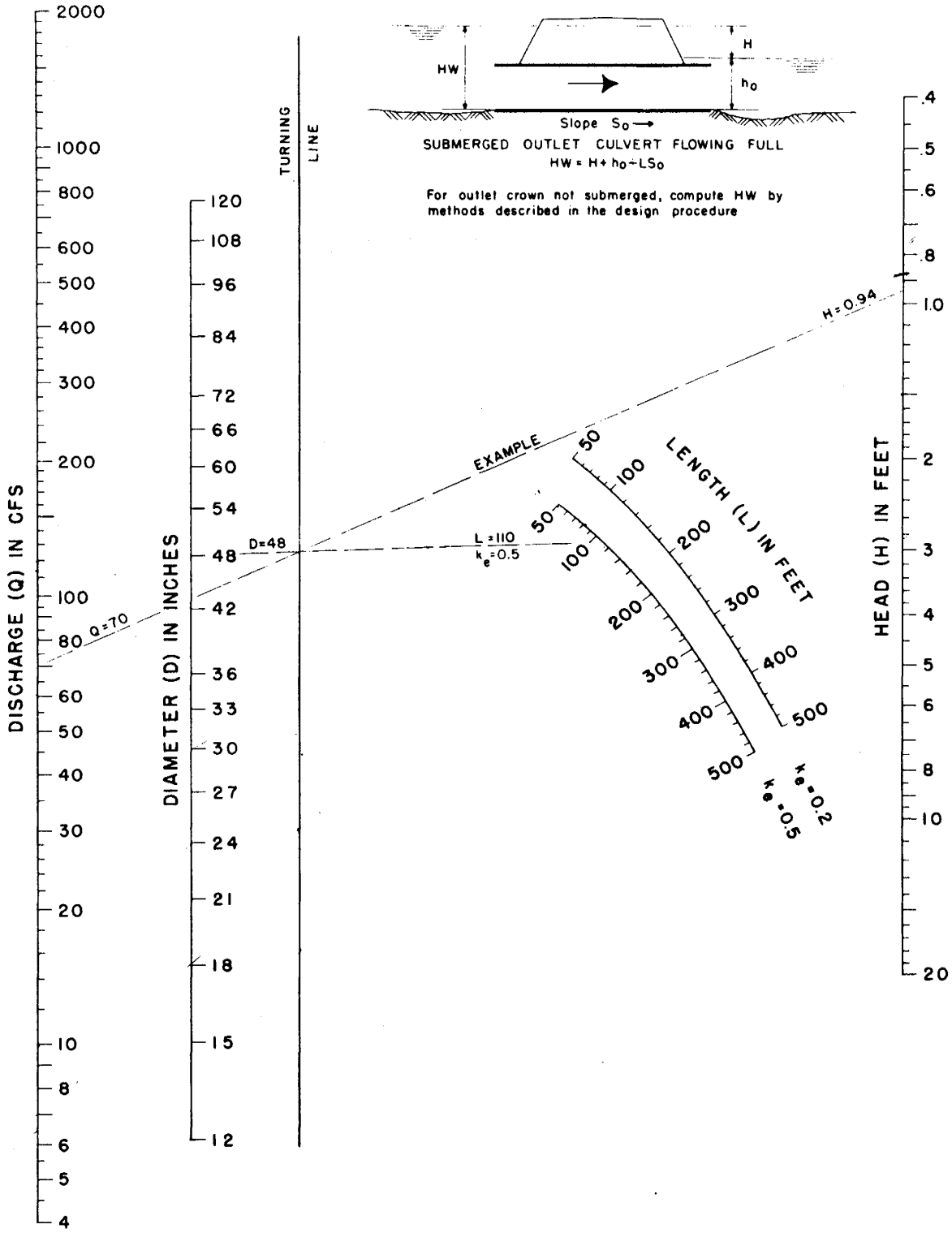
TABLE A — PROPERTIES OF DITCHES.

NO.	DIMENSIONS				HYDRAULICS			
	SIDE SLOPES	B	H	W	a	p	R	$R^{2/3}$
D-1	—	—	6½"	5'-0"	1.84	5.16	0.356	0.502
D-1A	12:1 & 2:1	—	6"	7'-0"	1.75	7.14	0.245	0.392
D-1B	12:1 & 2:1	—	5"±	7'-0"	1.64	7.08	0.232	0.377
D-1C	½" to 1'-0"	—	4.5"	10'-0"	1.68	10.38	0.162	0.297
D-2A	1½:1'	2'-0"	1'-0"	5'-0"	3.50	5.61	0.624	0.730
B	2:1	2'-0"	1'-0"	6'-0"	4.00	6.47	0.618	0.726
C	3:1	2'-0"	1'-0"	8'-0"	5.00	8.32	0.601	0.712
D-3A	1½:1	3'-0"	1'-6"	7'-6"	7.88	8.41	0.937	0.958
B	2:1	3'-0"	1'-6"	9'-0"	9.00	9.71	0.927	0.951
C	3:1	3'-0"	1'-6"	12'-0"	11.25	12.49	0.901	0.933
D-4A	1½:1	3'-0"	2'-0"	9'-0"	12.00	10.21	1.175	1.114
B	2:1	3'-0"	2'-0"	11'-0"	14.00	11.94	1.173	1.112
C	3:1	3'-0"	2'-0"	15'-0"	18.00	15.65	1.150	1.097
D-5A	1½:1	4'-0"	3'-0"	13'-0"	25.50	14.82	1.721	1.436
B	2:1	4'-0"	3'-0"	16'-0"	30.00	17.42	1.722	1.437
C	3:1	4'-0"	3'-0	22'-0"	39.00	22.97	1.698	1.423
D-6A	2:1	—	1'-0"	4'-0"	2.00	4.47	0.447	0.584
B	3:1	—	1'-0"	6'-0"	3.00	6.32	0.475	0.609
D-7A	2:1	—	2'-0"	8'-0"	8.00	8.94	0.895	0.929
B	3:1	—	2'-0"	12'-0"	12.00	12.65	0.949	0.965
D-8A	2:1	—	3'-0"	12'-0"	18.00	13.42	1.341	1.216
B	3:1	—	3'-0"	18'-0"	27.00	18.97	1.423	1.265
D-9	7:1	—	1'-0"	14'-0"	7.00	14.14	0.495	0.626
D-10	7:1	—	2'-0"	28'-0"	28.00	28.28	0.990	0.993
D-11	7:1	—	3'-0"	42'-0"	63.00	42.43	1.485	1.302

DRAINAGE-DITCHES-COMMON SECTIONS-2



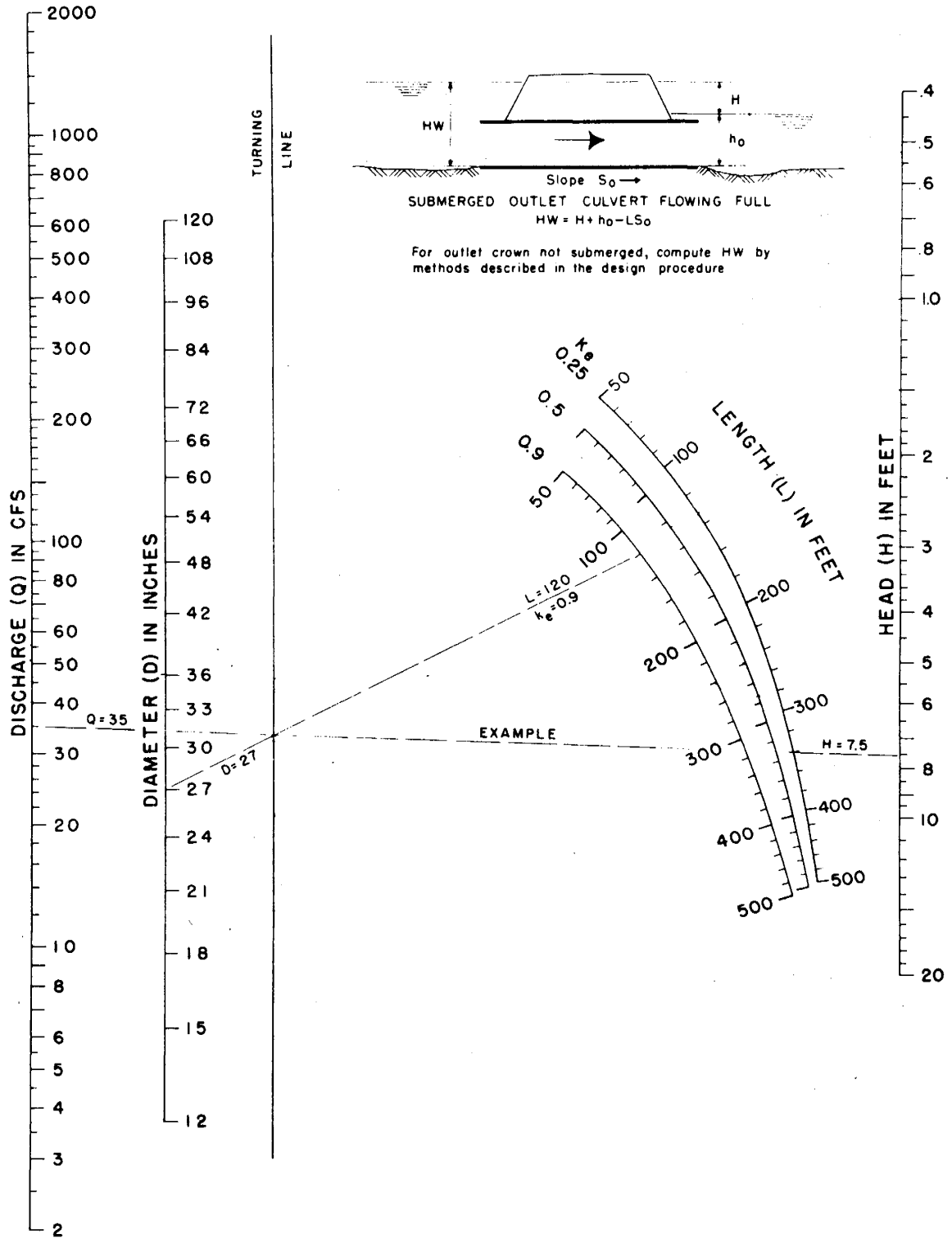
*See page 31 for ditch types



HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 8

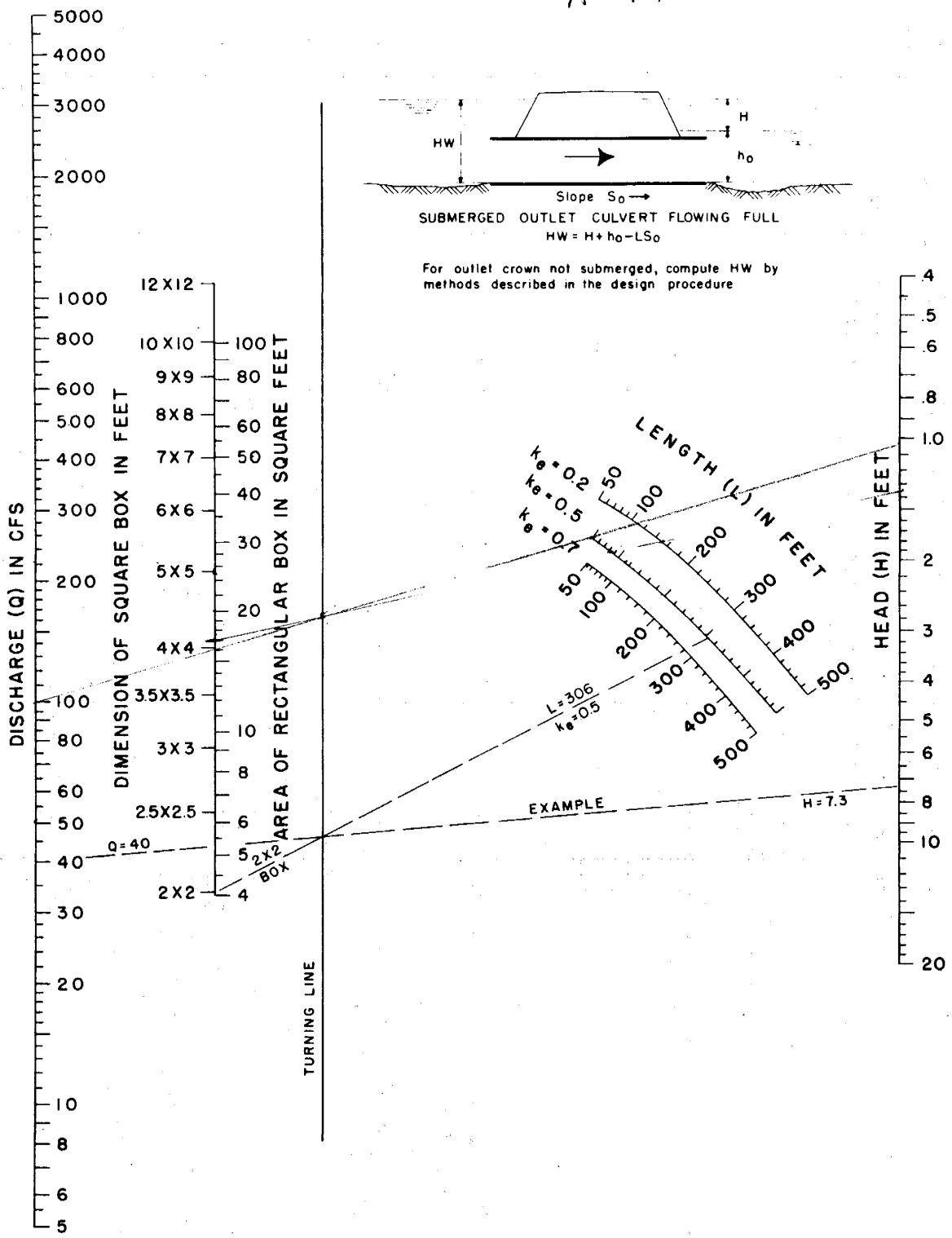


HEAD FOR STANDARD C. M. PIPE CULVERTS FLOWING FULL n = 0.024

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 9

A=17



HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 10

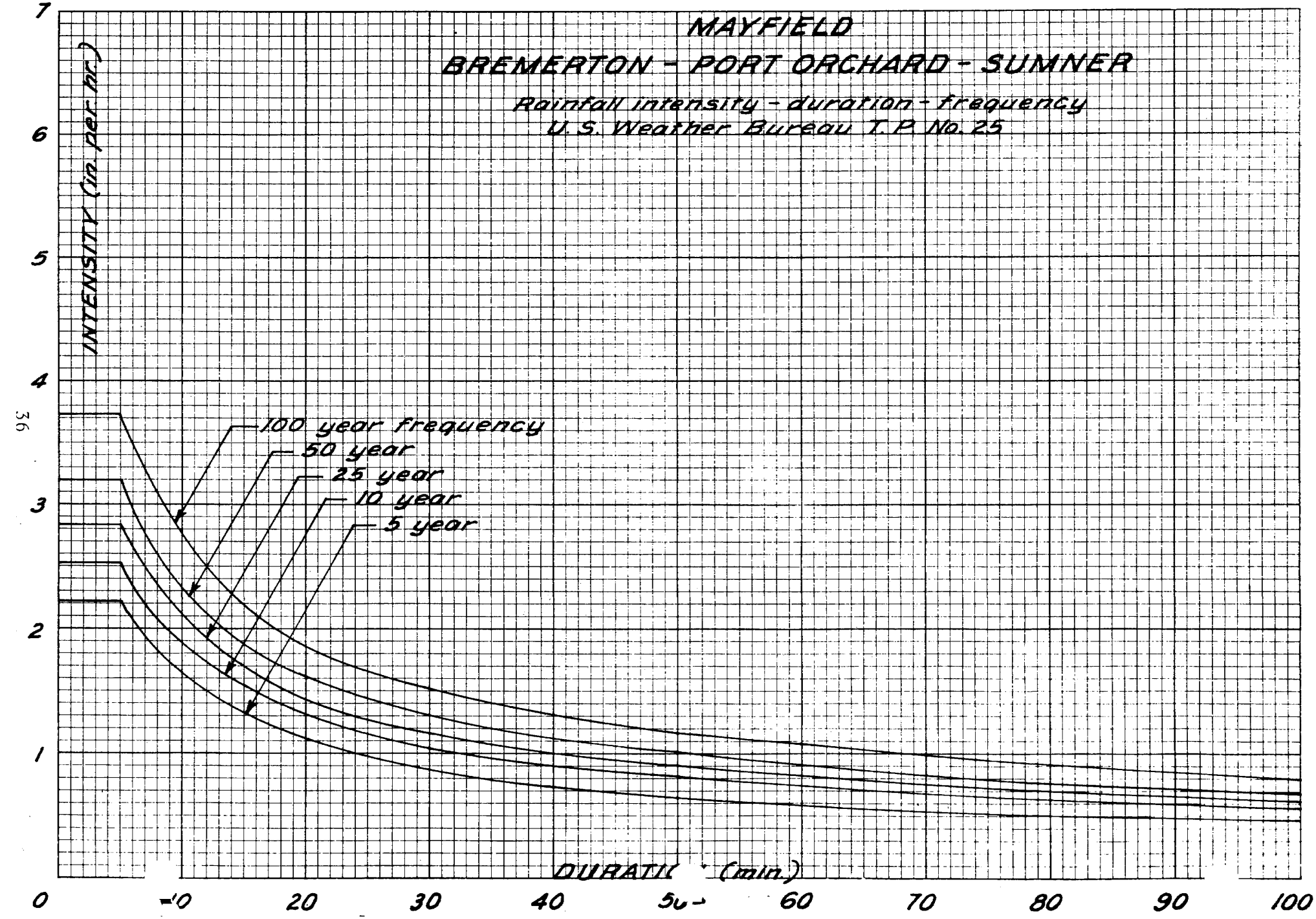

MAYFIELD
BREMERTON - PORT ORCHARD - SUMNER
Rainfall intensity - duration - frequency
U.S. Weather Bureau T.P. No. 25
INTENSITY (in. per hr.)
100 year frequency
50 year
25 year
10 year
5 year
DURATION (min.)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7

CHART 11

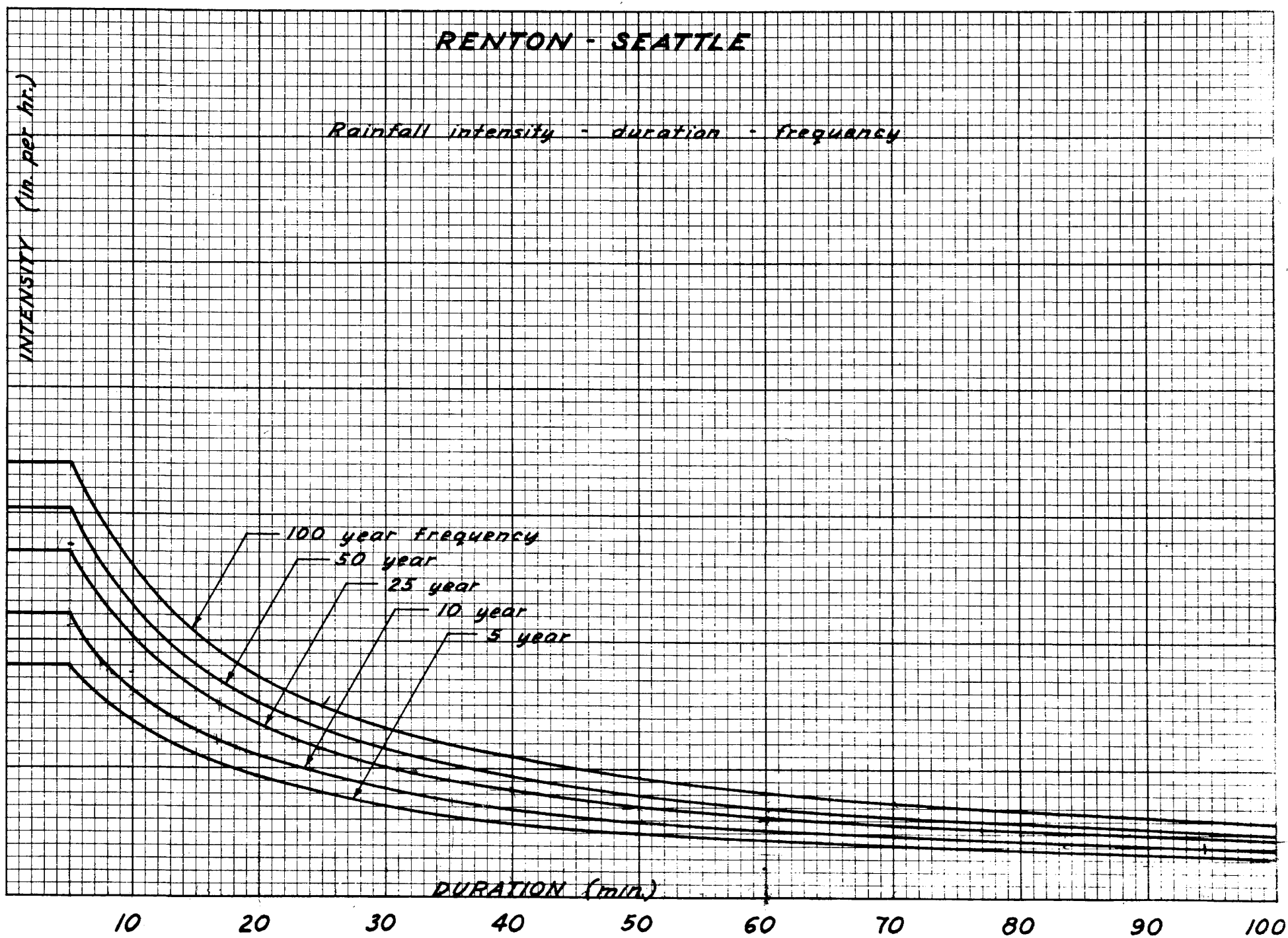

RENTON - SEATTLE
Rainfall intensity - duration - frequency
INTENSITY (in. per hr.)
DURATION (min.)
100 year frequency
50 year
25 year
10 year
5 year
0
1
2
3
4
5
6
7
10
20
30
40
50
60
70
80
90
100

CHART 12

100 YR PRECIPS
3HR- 1.23"
6HR- 1.71"
12HR- 2.52"
24HR- 3.72"

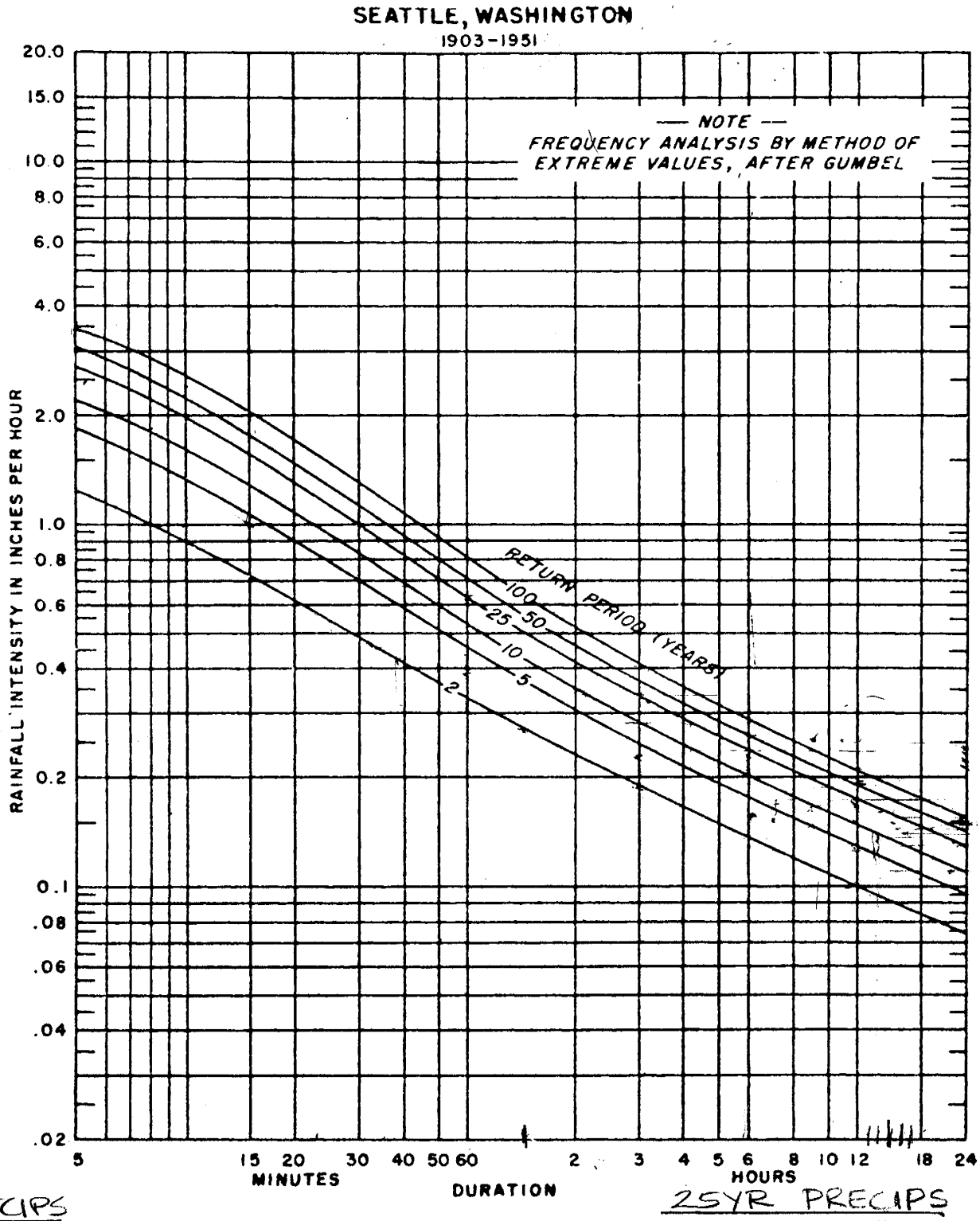
CHART 13

10 YR PRECIPS
3HR- 0.84"
6HR- 1.20"
12HR- 1.76"
24HR- 2.64"

PRECIPITATION

GRAPH B

RAINFALL INTENSITY - DURATION - FREQUENCY CURVES



2YR PRECIPS
3HR- 0.56"
6HR- 0.81"
12HR- 1.20"
24HR- 1.78"

This graph is for use in estimating runoff and the frequency of various rainfall intensities in the Seattle area. For example: Rain lasting 5 hours at the average rate of 0.2 inch per hour can be expected about once in 7 years, while about once in 25 years a rain of intensity 1.0 inch per hour can be expected to last for 30 minutes.

Source: Weather Bureau Technical Paper No.25.
Rainfall Intensity-Duration-Frequency Curves. December 1955
(Hydrologic Services Division)

25YR PRECIPS
3HR- 1.00"
6HR- 1.42"
12HR- 2.06"
24HR- 3.12"

CHART 13

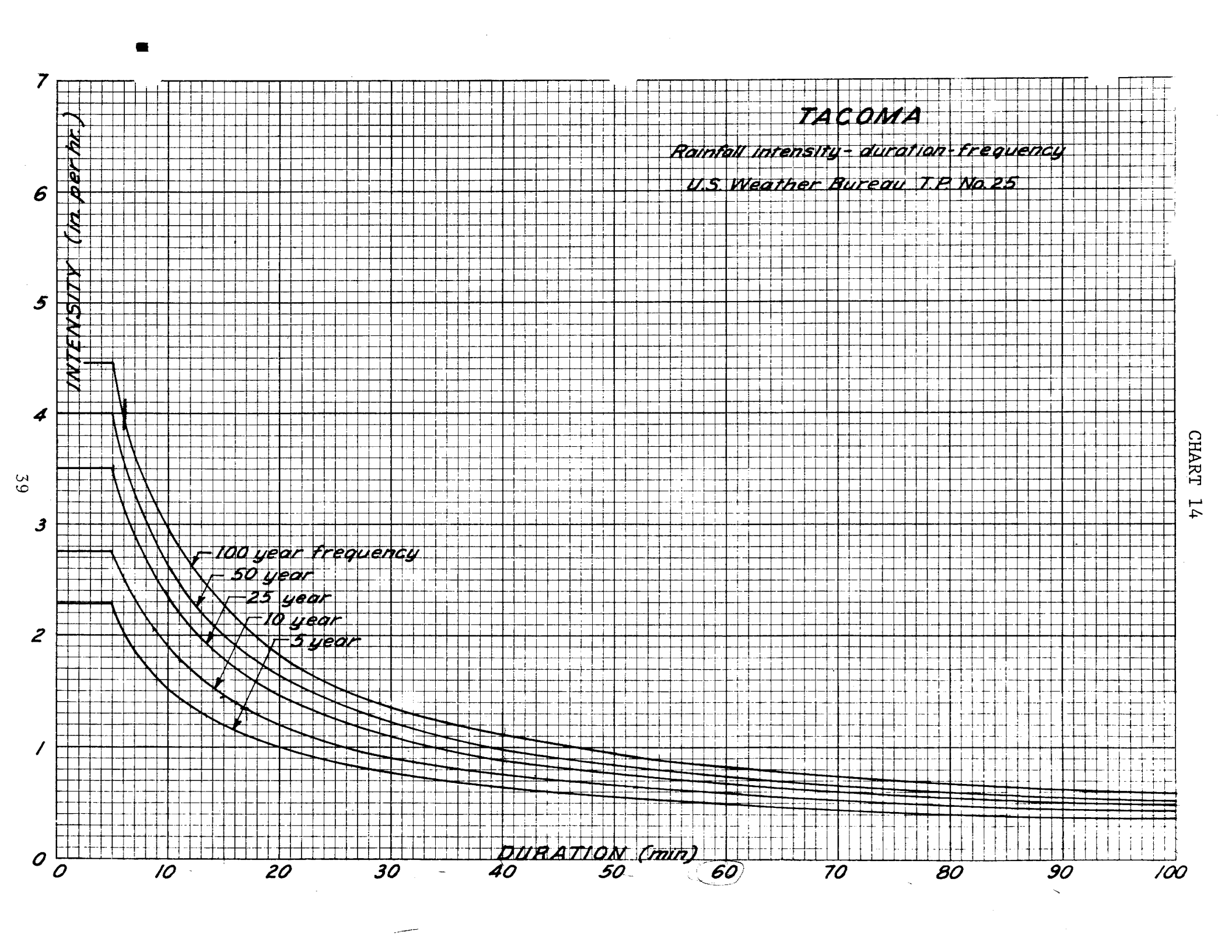

TACOMA
Rainfall intensity - duration - frequency
U.S. Weather Bureau T.P. No. 25
INTENSITY (in. per hr.)
DURATION (min)
100 year frequency
50 year
25 year
10 year
5 year
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80
90
100

CHART 14

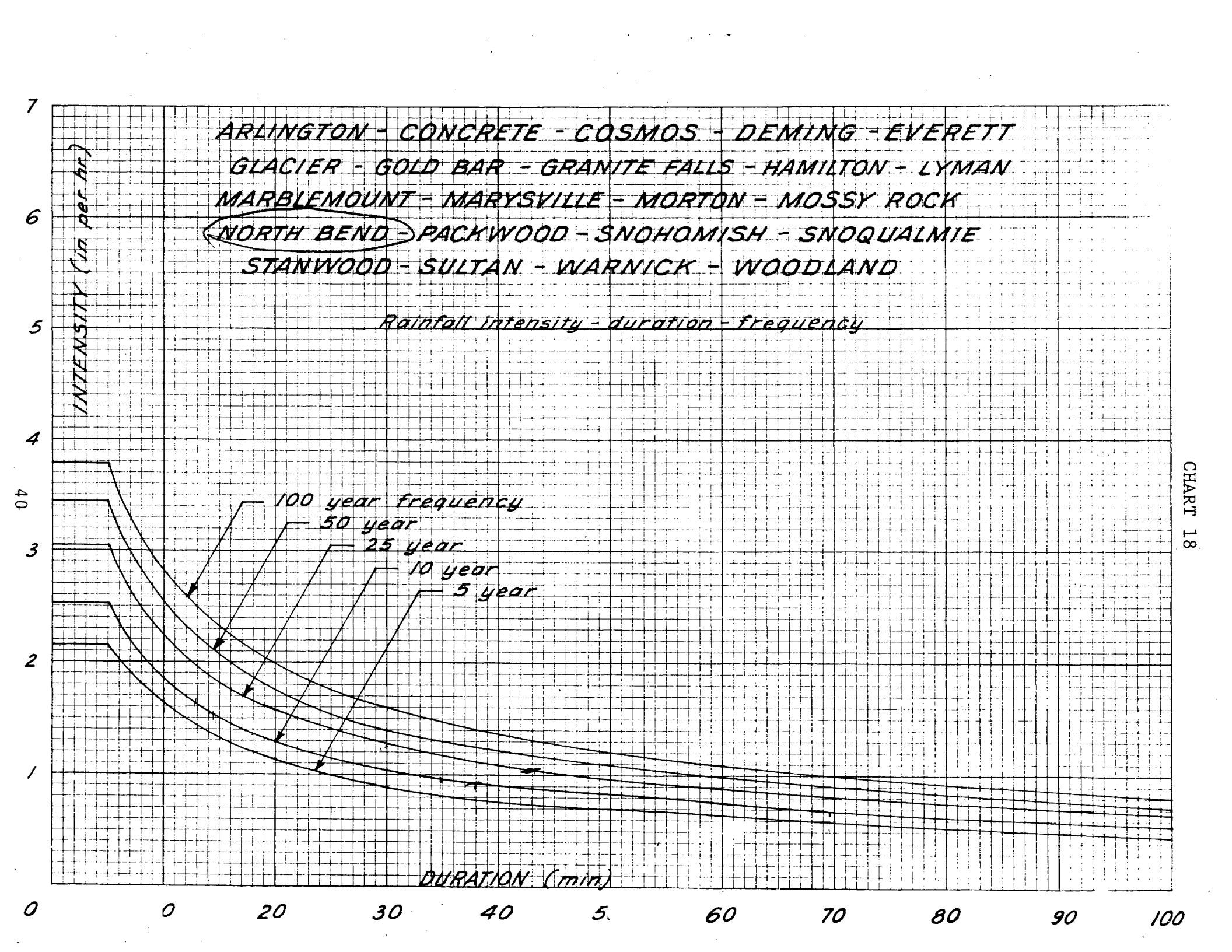

ARLINGTON - CONCRETE - COSMOS - DEMING - EVERETT
GLACIER - GOLD BAR - GRANITE FALLS - HAMILTON - LYMAN
MARBLEMOUNT - MARYSVILLE - MORTON - MOSSY ROCK
NORTH BEND - PACKWOOD - SNOHOMISH - SNOQUALMIE
STANWOOD - SULTAN - WARNICK - WOODLAND
Rainfall intensity - duration - frequency
INTENSITY (in per hr)
100 year frequency
50 year
25 year
10 year
5 year
DURATION (min.)
0
1
2
3
4
5
6
7
0
20
30
40
60
70
80
90
100

CHART 18

40

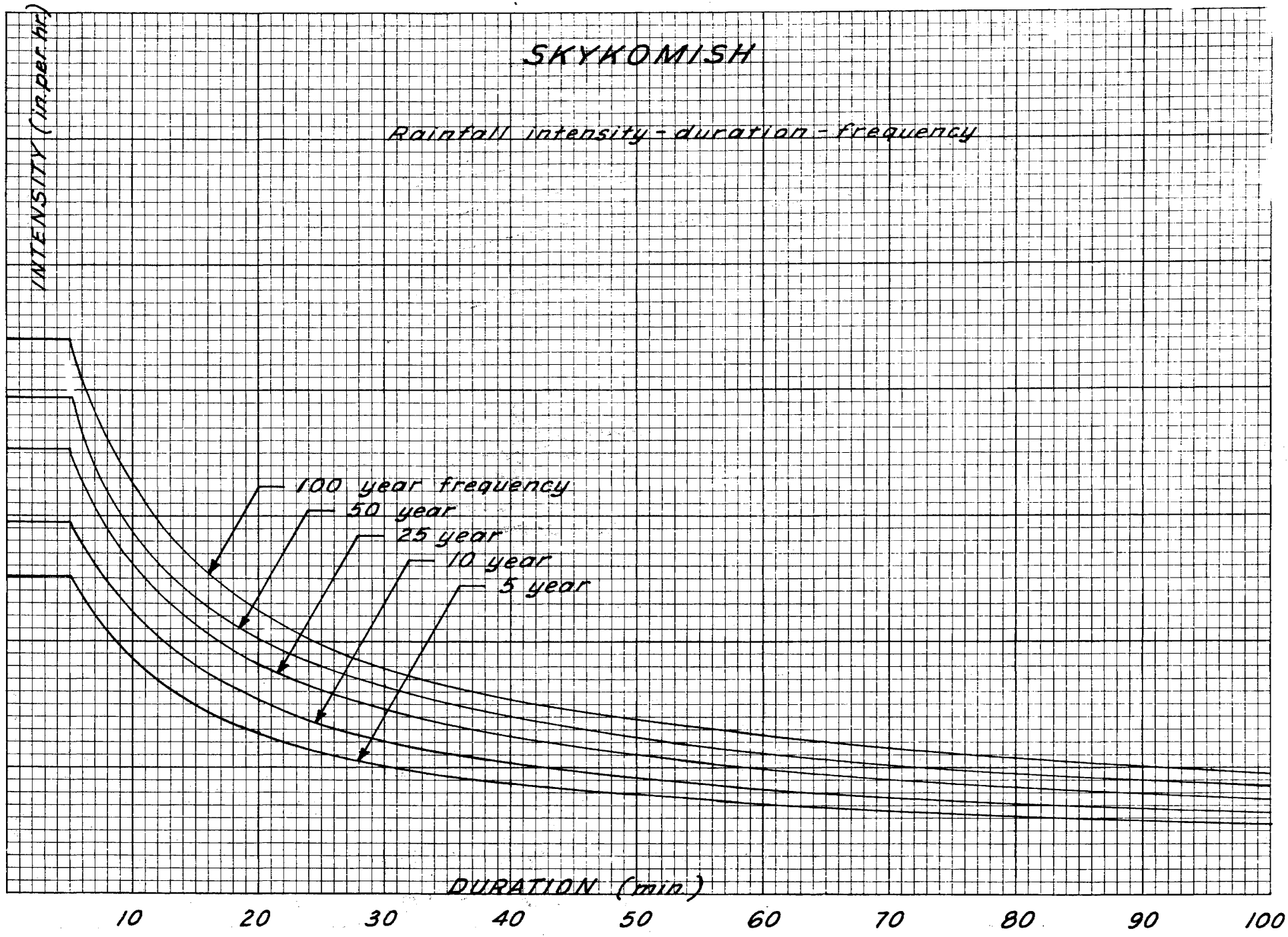

SKYKOMISH
Rainfall intensity - duration - frequency
INTENSITY (in per hr.)
DURATION (min.)
100 year frequency
50 year
25 year
10 year
5 year
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7

CHART 21

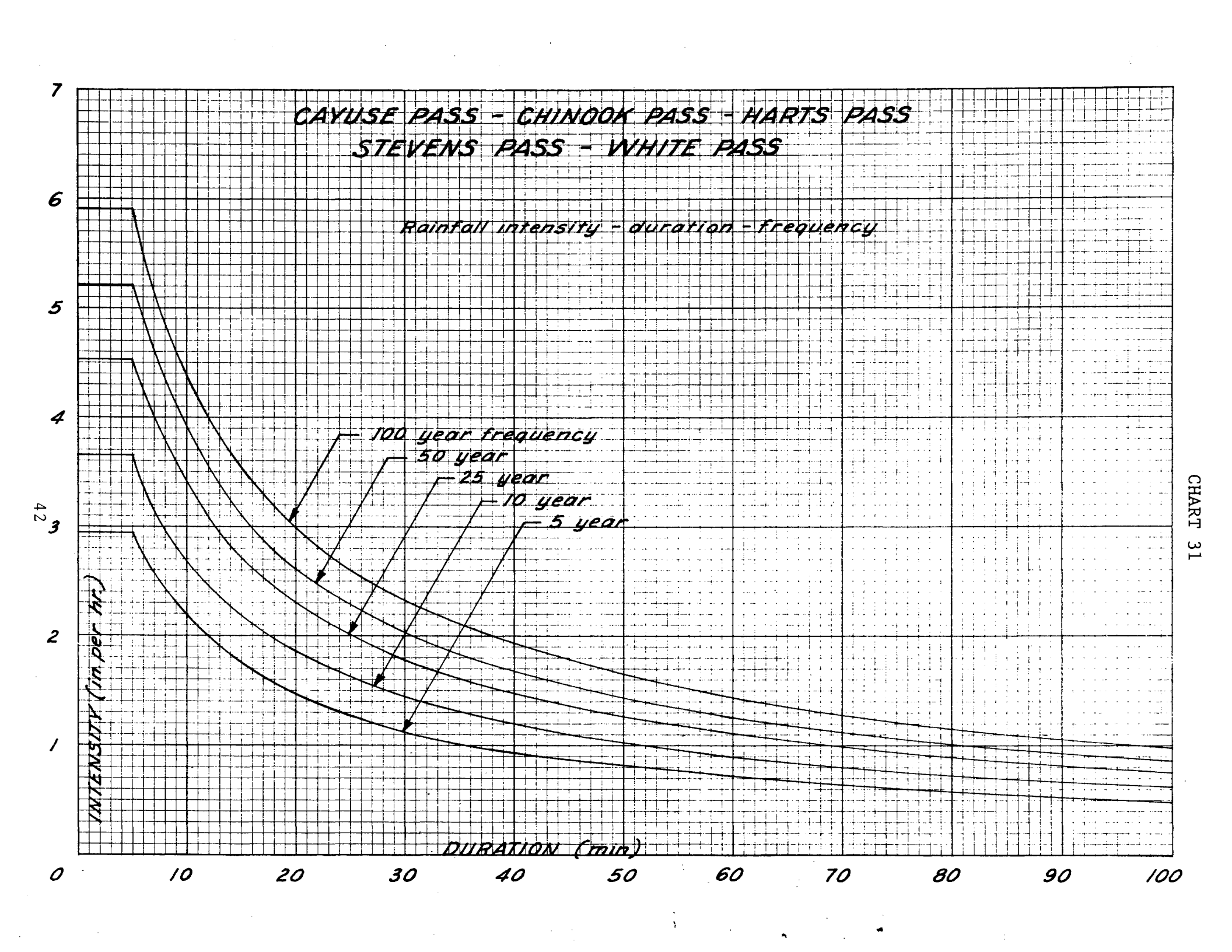

CAYUSE PASS - CHINOOK PASS - HARTS PASS
STEVENS PASS - WHITE PASS
Rainfall intensity - duration - frequency
100 year frequency
50 year
25 year
10 year
5 year
INTENSITY (in per hr.)
DURATION (min)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7

CHART 31

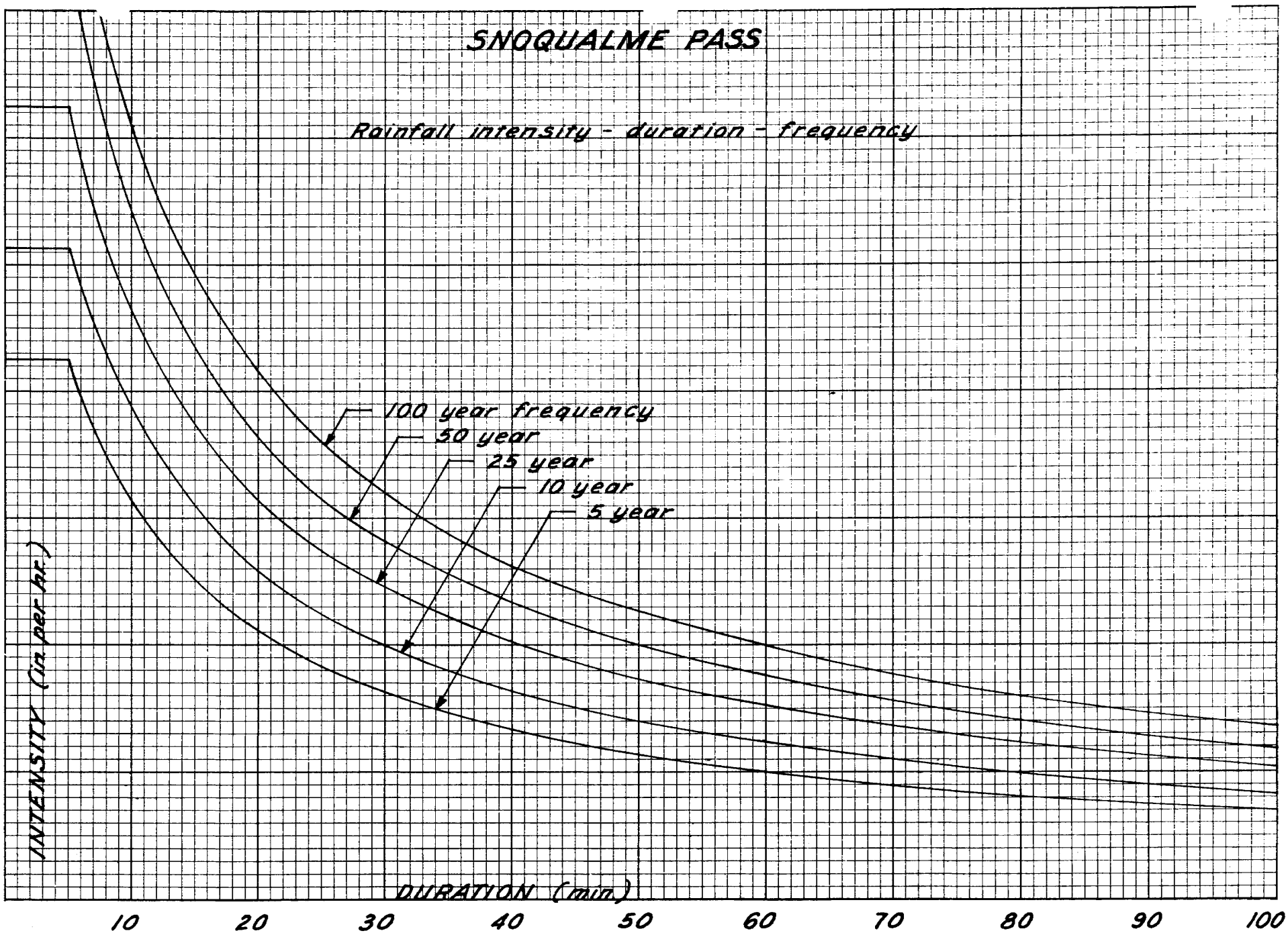
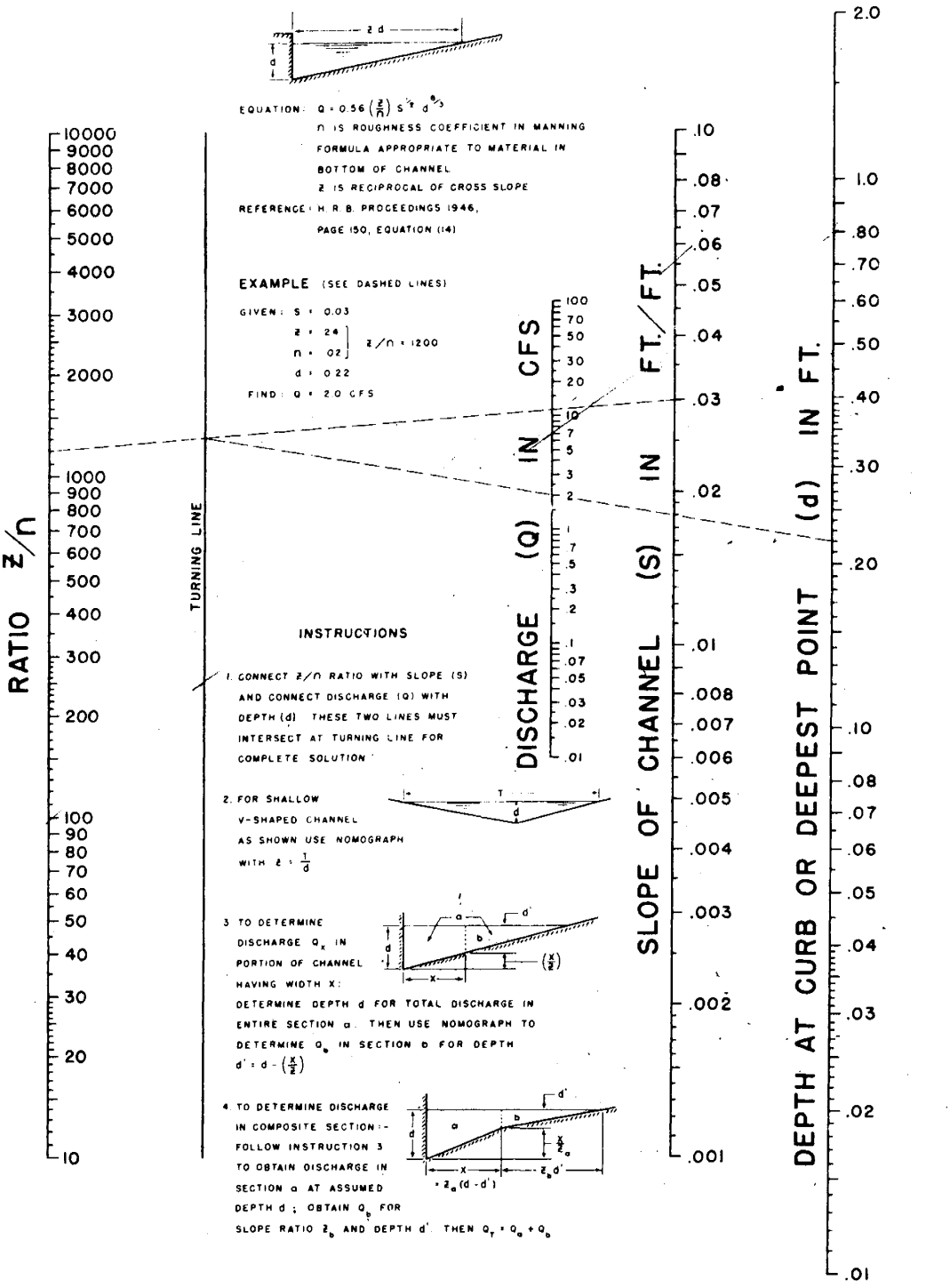

SNOQUALME PASS
Rainfall intensity - duration - frequency
100 year frequency
50 year
25 year
10 year
5 year
INTENSITY (in per hr.)
DURATION (min.)
0
1
2
3
4
5
6
7
10
20
30
40
50
60
70
80
90
100

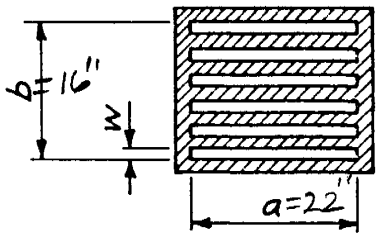
CHART 33



NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS

CHART 34

4.8 CFS @ 0.4' Hd.



$P = 2(a+b)$

Standard
P = 6.33

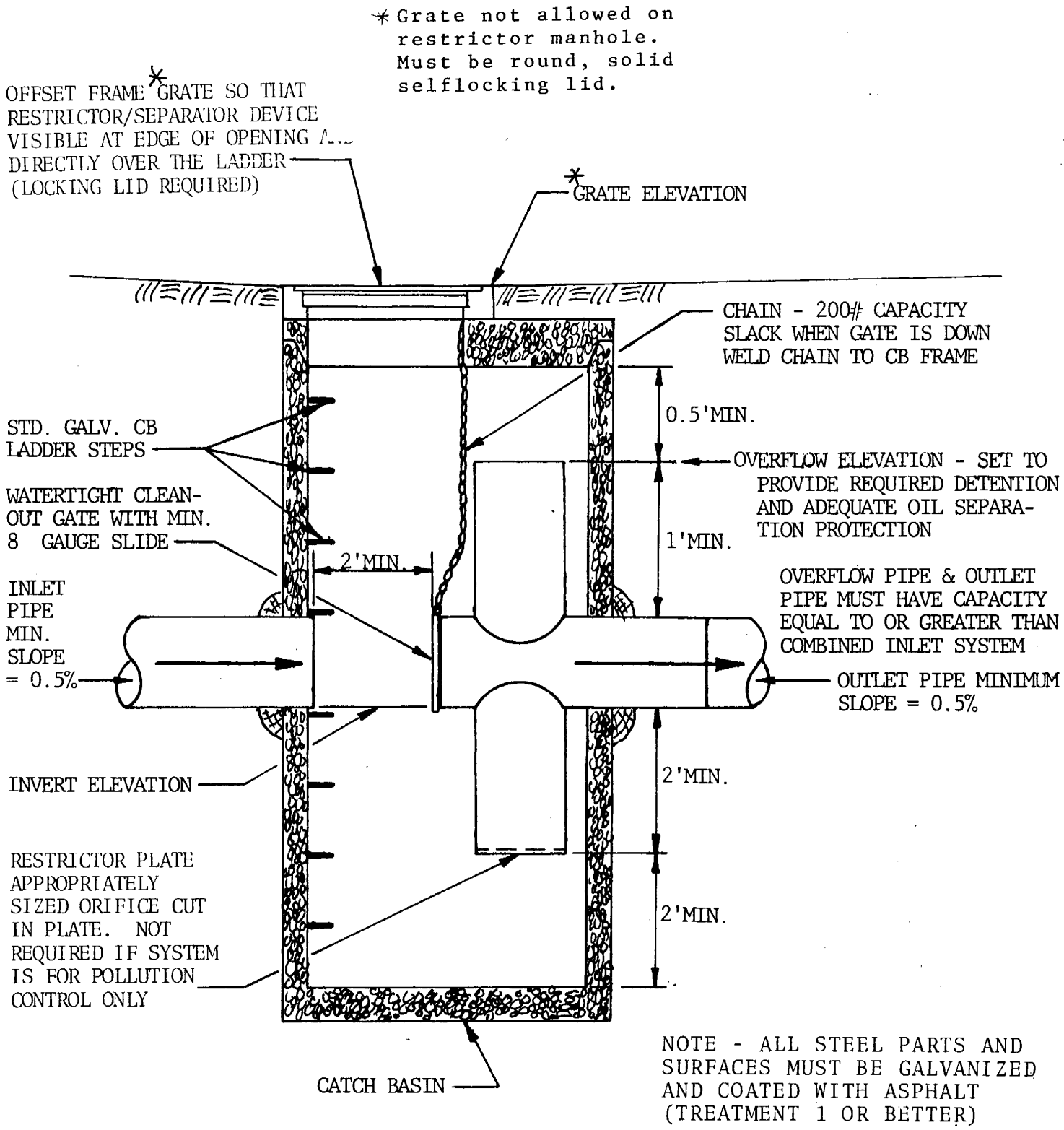
BUREAU OF PUBLIC ROADS

CAPACITY OF GRATE INLET IN SUMP

Standard Grate
$Q = 19.0H^{1.5}$

CHART 35

*DESIGN FOR A MAX.
1.0 CFS/GRATE
@ 0.14 feet



FLOW RESTRICTOR/OIL SEPARATOR CONTROL DEVICE/CATCH BASIN

FIGURE 1

TEMPORARY EROSION/SEDIMENTATION CONTROL NOTES & PLAN:

1. Where possible, maintain natural vegetation to minimize erosion.

2. All temporary siltation and detention ponds shall be maintained in a satisfactory condition until such time that clearing and/or construction is completed and the permanent drainage facilities are operational.

3. Return siltation control areas to original ground conditions.

4. Approval of this plan does not constitute an approval of design, size nor location of pipes, restrictors, channels or retention facilities; but is an approval of temporary sedimentation control plan only.

5. Once work has stopped in any area stripped of vegetation for a period not to exceed 60 days, it must be stabilized with grass or other erosion control treatment. Seeding can be used only between the months of April and October.

6. A minimum 3 foot high fence is required around all temporary erosion sedimentation control ponds when the dead storage depth exceeds 6 inches.

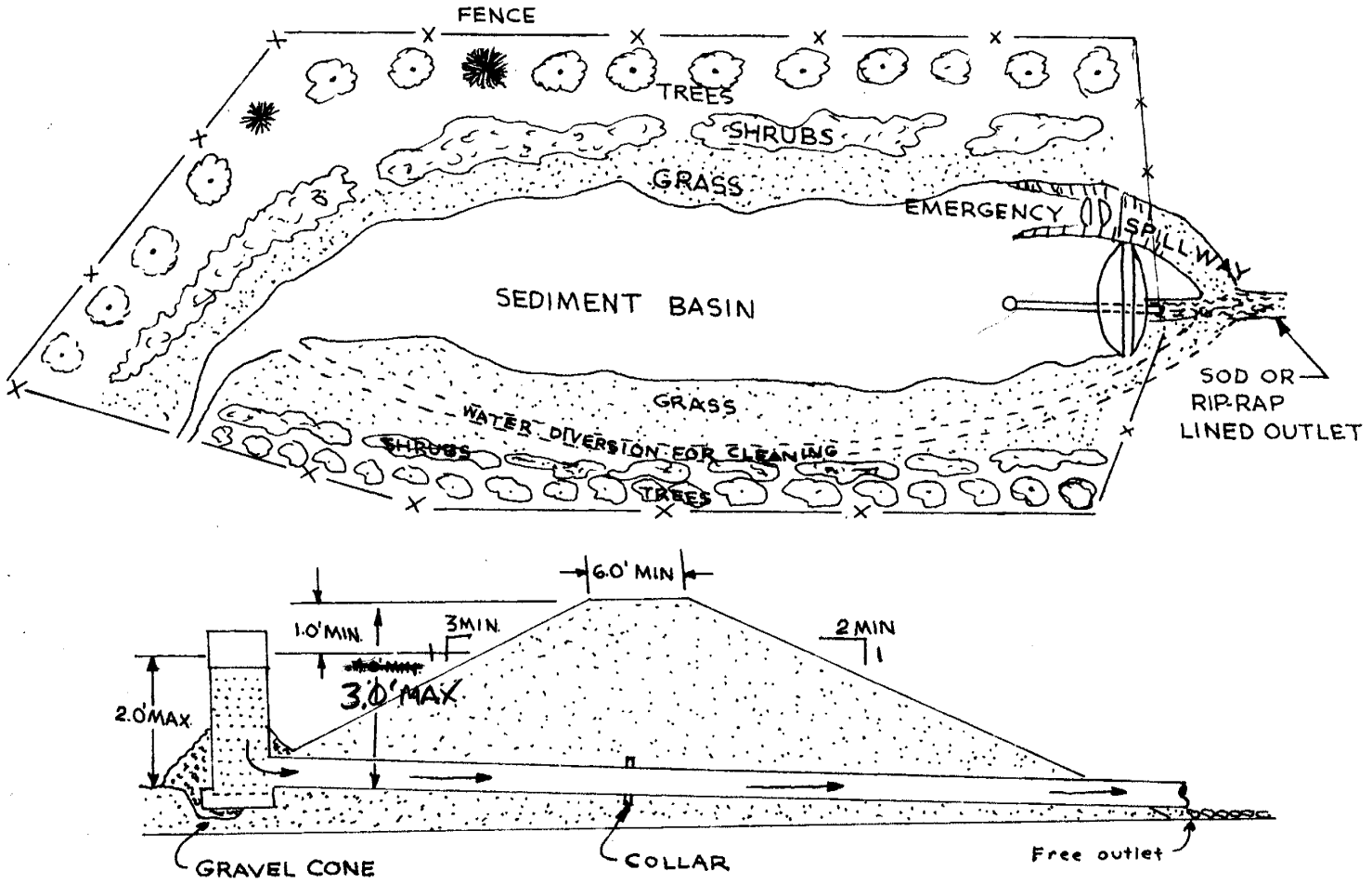
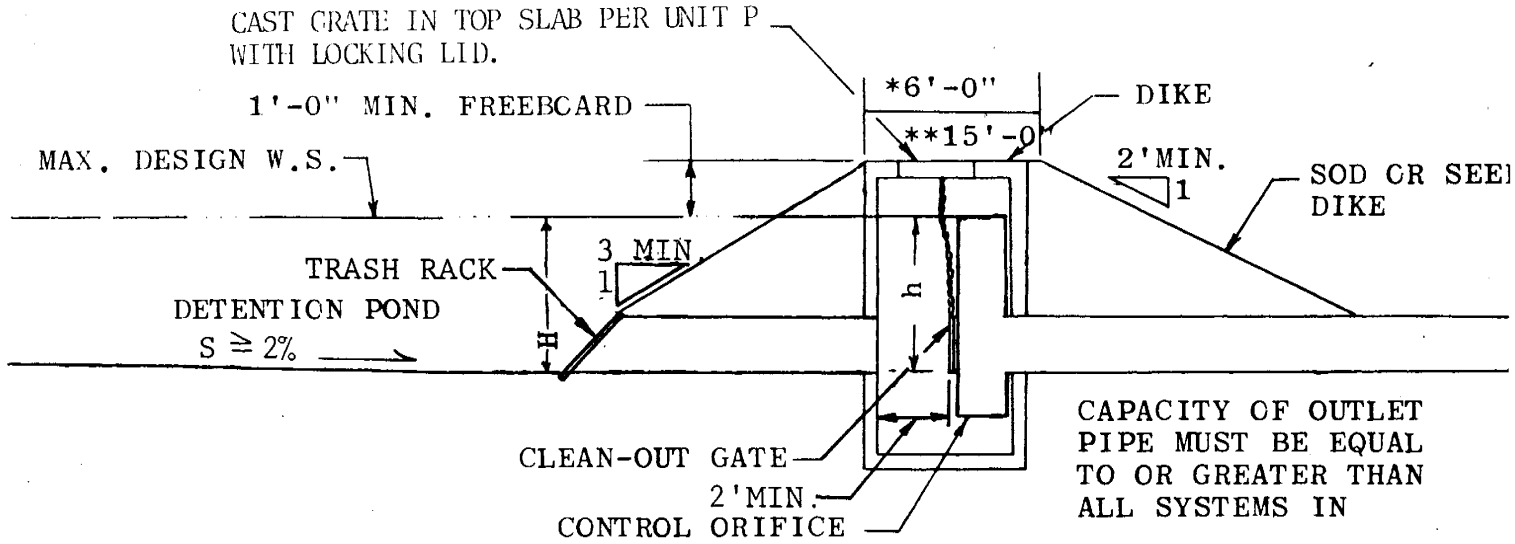


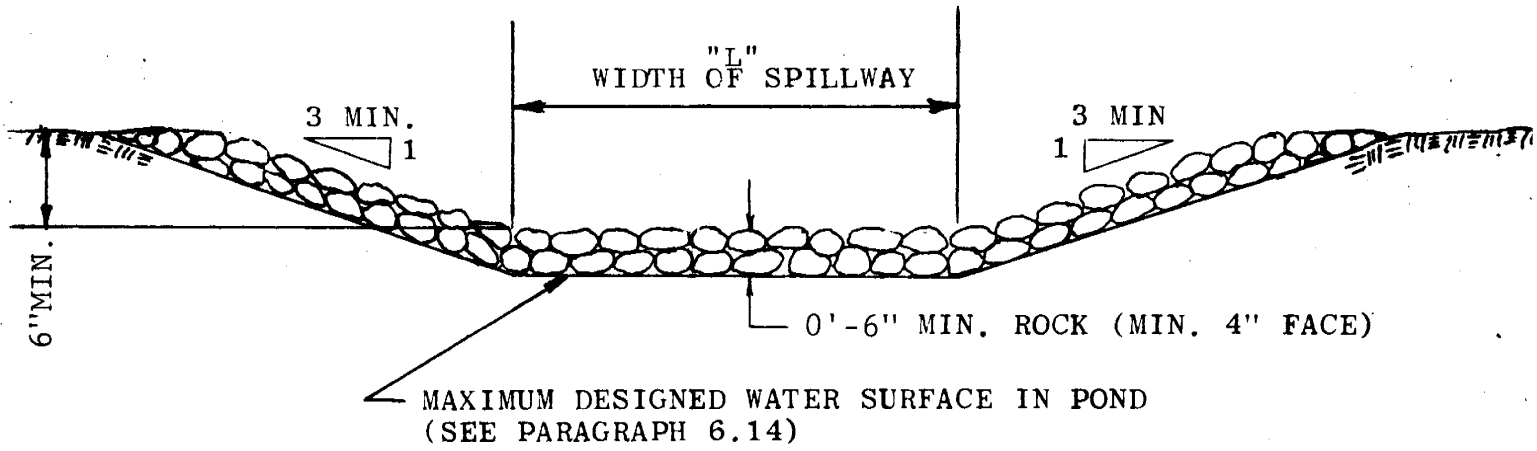
FIGURE 2

5/79

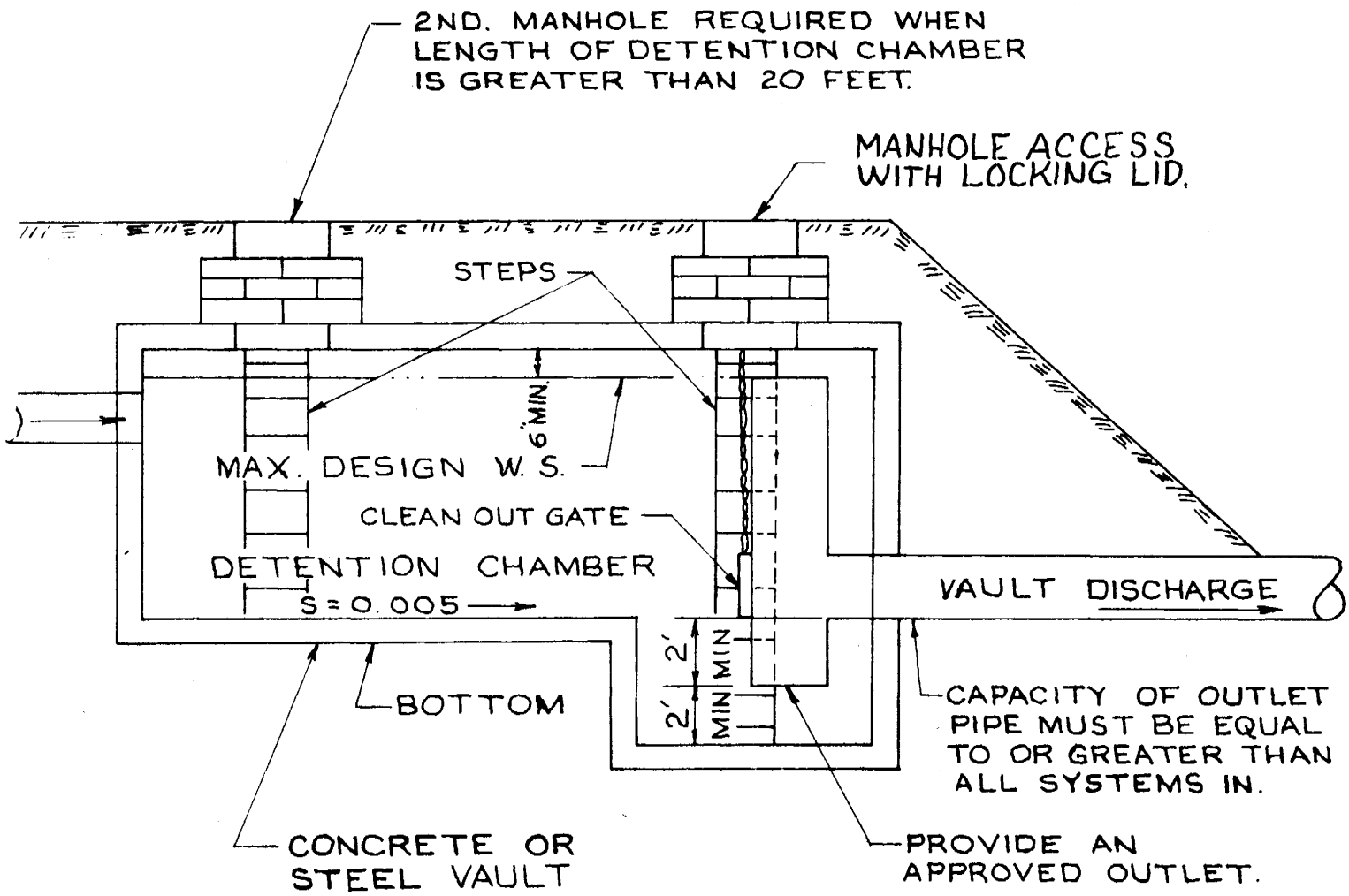


* 6' MIN. WHEN "H" LESS THAN 3'
** 15' MIN. WHEN "H" GREATER THAN 3'

TYPICAL DETENTION POND OUTLET
Figure 3



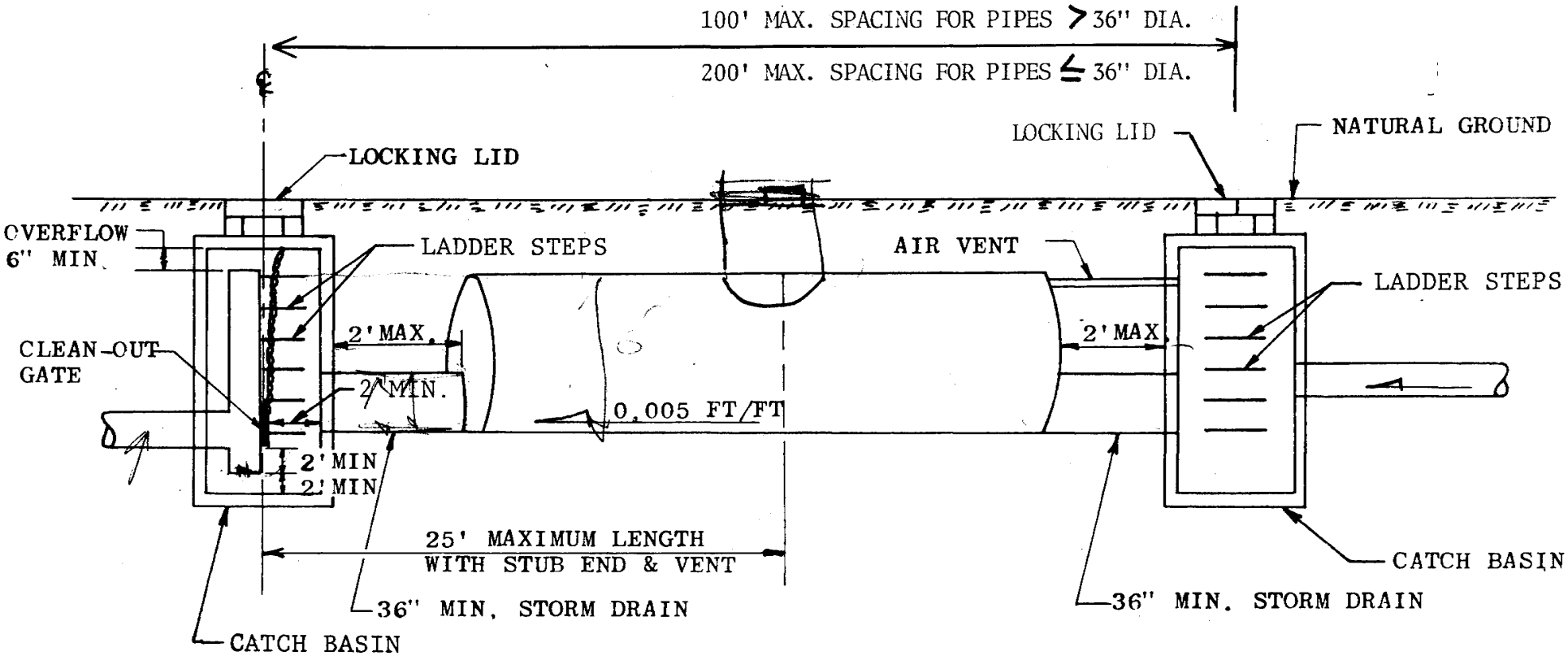
TYPICAL POND OVERFLOW SPILLWAY
Figure 4



ALL STEEL PARTS MUST BE GALVANIZED AND ASPHALT COATED (TREATMENT 1 OR BETTER).

TYPICAL CLOSED DETENTION VAULT

Figure 5

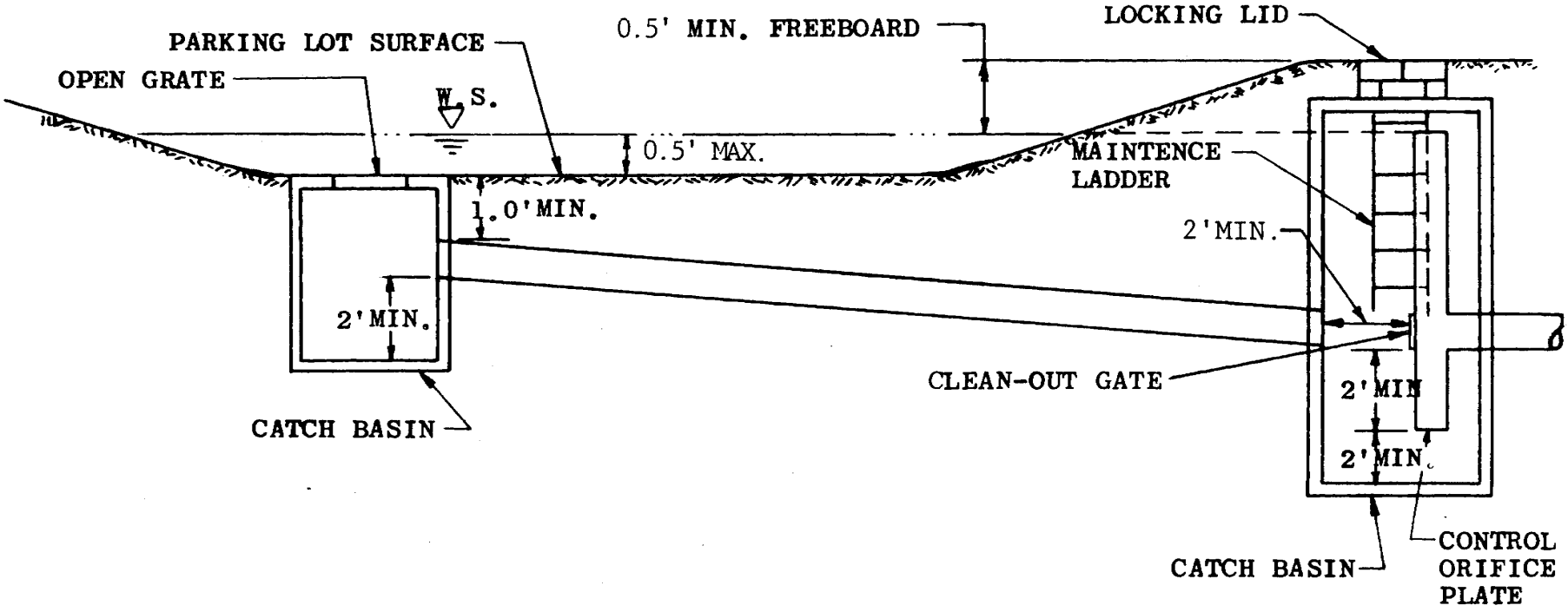


48" TYPE II – MAX. PIPE SIZE = 21"
54" TYPE II – MAX. PIPE SIZE = 36"
72" TYPE II – MAX. PIPE SIZE = 48"
96" TYPE II – MAX. PIPE SIZE = 60"

ALL STEEL PARTS MUST BE GALVANIZED AND ASPHALT COATED (TREATMENT 1 OR BETTER).

TYPICAL CLOSED DETENTION PIPE

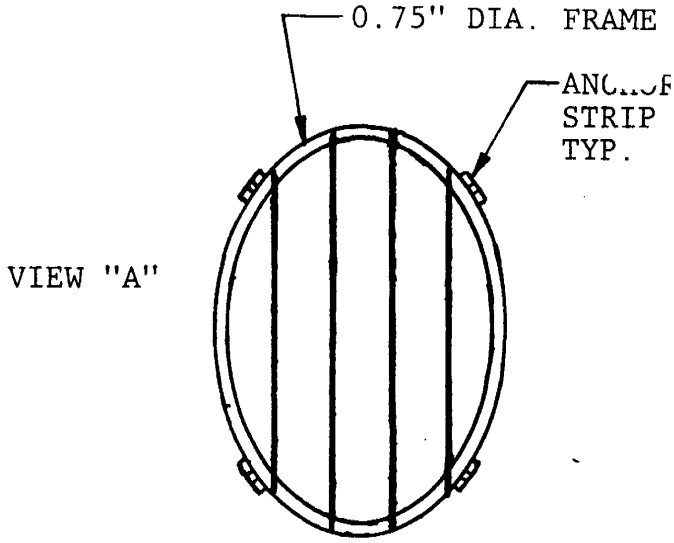
FIGURE 6

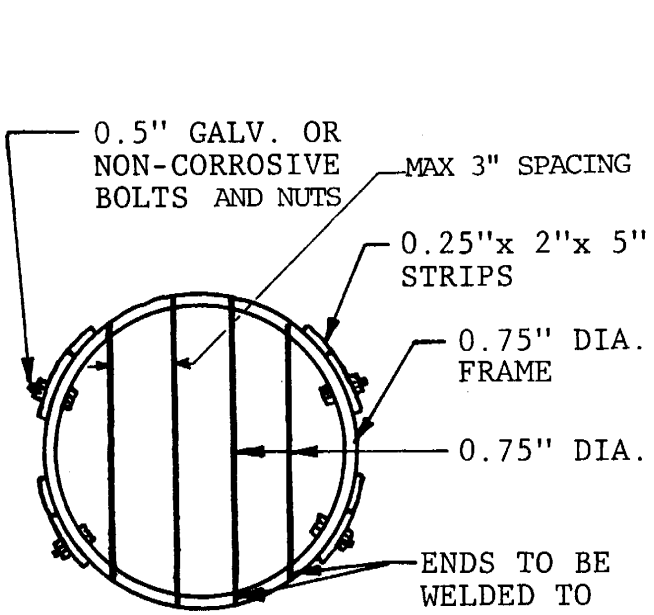


NOTE: NO PONDING IN SERVICE ROADS/LANES AND IN RESIDENTIAL DEVELOPMENTS

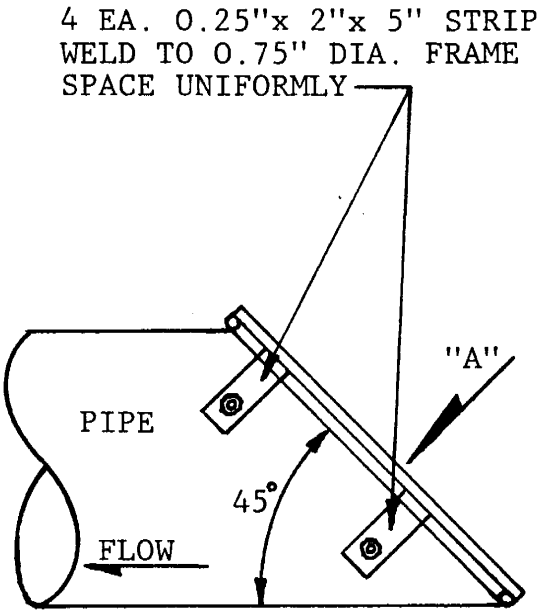
TYPICAL PARKING LOT PONDING

FIGURE 7





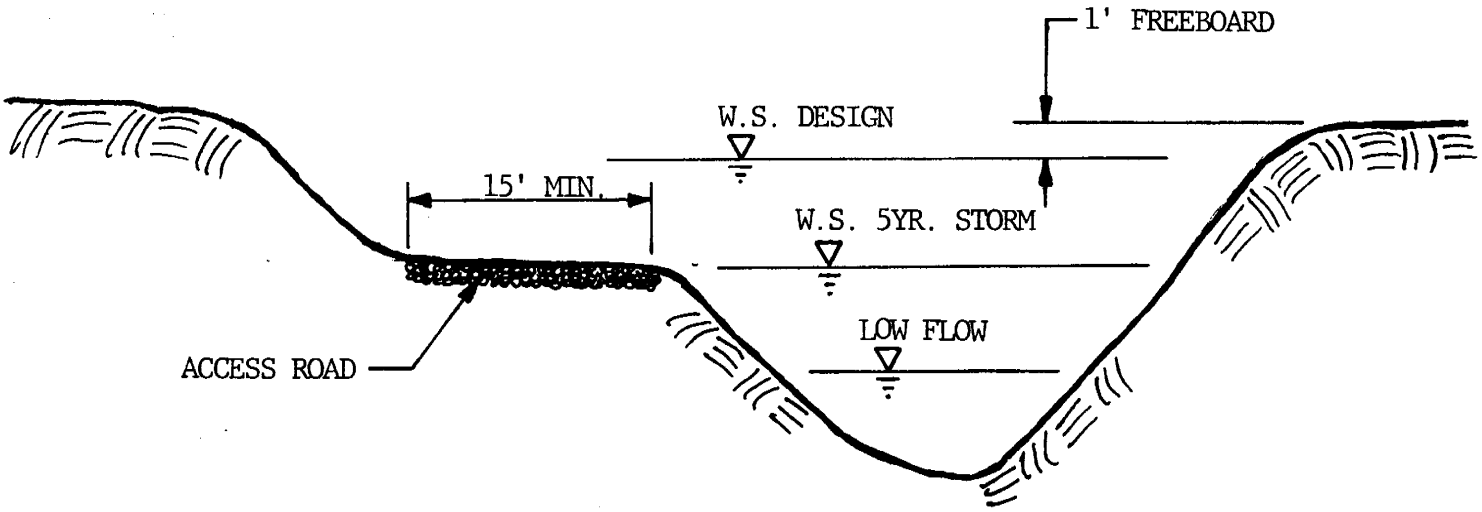
END VIEW



ALL STEEL PARTS MUST BE GALVANIZED AND ASPHALT COATED (TREATMENT 1 OR BETTER).

TYPICAL
DEBRIS BARRIER

FIGURE 8



TYPICAL CHANNEL-
MAINTENANCE ROAD

FIGURE 9

RUNOFF COMPUTATIONS

SYSTEM NO. Sample SHEET 1 OF DESIGN STORM 10yr.

LOCATION Page 8 K.C. Hyd. Manual By: Jerry Creek Date: 6May77
Ckd: Ed M. Andrusky 5/9/3

AREA To (1)	AREA FROM (2)	LENGTH (3)	FEET/SEC. FLOW (4)	FLOW TIME (MIN.) (5)	CONC. TIME (MIN.) (6)	TOTAL TIME (MIN.) (7)	ACRE / TOTAL AREA (8)	AREA PER RUNOFF COEFF. C ACRES C=0.40 (9)	C= (10)	C= (11)	ACRE X C 0.40 (12)	ACRES X C (13)	ACRES X C (14)	TOTAL ACRES X C (15)	RAINFALL INTENSITY IN. PER HR. (16)	RUNOFF CFS (15) (16) (17)	PIPE SIZE (18)
A	1	420 165	1 2	7 1.4	10	18.4	5.0 / 5.0	5			2			2	1.15	2.30	
Inlet @ CB 2	Culvert A + 3	260	2	2.2	18.4	20.6	1.8 / 6.8	1.8			0.72			2.72	1.05	2.86	
CB I	2	300 350	1 2	5.0 2.9	10	17.9	4.3 / 4.3	4.3			1.72			1.72	1.15	1.98	
CB #2	CB #1 + Inlet @ CB 2	0	0	0	20.6	20.6	0 / 11.1	0			0			4.44	1.05	4.66	
Inlet 3A	4	240 180	1 2	4 1.5	10	15.5	1 / 1	1			0.4			0.4	1.25	0.50	
CB #3	Inlet 3A + 5	30	2	0.25	15.5	15.75	1.1 / 2.1	1.1			0.44			0.84	1.25	1.05	
Inlet 4A	6	200	1	3.33	10	13.3	0.5 / 0.5	0.5			0.2			0.2	1.4	0.28	
CB #4	CB #3 CB #2 Inlet 4A	40	2	0.33	20.6	20.9	0 / 13.7	0			0			5.48	1.05	5.75	
Inlet 5A	7	240	1	4	10	14	0.8 / 0.8	0.8			0.32			0.32	1.4	0.45	
CB #5	CB #4 Inlet 5A 8	300	5.5	0.9	20.9	21.8	1.3 / 15.8	1.3			0.52			6.32	1.01	6.33	

LOCATION		INCREMENTAL AREA A	RUN-OFF COEFFIC. C	AC	Σ AC	TIME OF CONCENTRATION TC	RAINFALL INTENSITY I	RUN-OFF Q (Σ AC I)	PIPE DIA.	SLOPE	VELOCITY AT DESIGN Q	LENGTH	FLOW TIME IN SYSTEM	UPPER ELEVATION		LOWER ELEVATION	
FROM	TO	ACRES				MINUTES	INCHES/HR.	C.F.S.	INCHES	%	F.P.S.	FEET	MIN.	GROUND	INVERT	GROUND	INVERT

USWB. CHART NO.: _____

STORM FREQUENCY: _____

PIPE COEFFICIENT: _____

_____

NAME OF PROJECT

CALCULATIONS BY: _____

REMARKS: _____

JOB NO. _____ DATE _____ SHEET _____ OF _____ SHEETS

drainage policies &/or recommendations

section C

drainage policies &/or recommendations

section C

SECTION		PAGE
1.	GENERAL REQUIREMENTS.	PR 1
2.	DEFINITION OF TERMS	PR 4
3.	TEMPORARY EROSION/SEDIMENTATION CONTROL	PR 5
4.	NATURAL & CONSTRUCTED CHANNELS.	PR 9
5.	CLOSED SYSTEMS & OTHER STRUCTURES	PR 11
6.	OPEN RETENTION/DETENTION PONDS.	PR 13
7.	CLOSED DETENTION PONDS.	PR 16
8.	INFILTRATION SYSTEM	PR 17
9.	RIGHT OF WAY EASEMENTS.	PR 18
10.	STANDARDS FOR PLAT SUBMITTALS	PR 20

SECTION 1 - GENERAL REQUIREMENTS

1.1 The temporary erosion/sedimentation control facility shall be constructed prior to any grading or extensive land clearing in accordance with the approved temporary erosion/sedimentation control plan. These facilities must be satisfactorily maintained until construction and landscaping is completed and the potential for on-site erosion has passed. (Add this note on temporary erosion/sedimentation control and final drainage plans).

1.2 All required storm water retention/detention facilities must be constructed and in operation prior to paving and building construction unless otherwise approved by the Department of Public Works. (Add this note on final drainage plan.)

1.3 In those cases where no runoff leaves the site for a storm greater than a 100 year frequency, the engineer is required to design the development to retain the 100 year frequency storm with no runoff. The overflow after the 100 year frequency storm must be situated where it would have overflowed under the existing condition.

1.4 The capacity of the downstream drainage course is required to be evaluated for a minimum distance of 1/4 mile from the point of discharge of the development. This system should be shown on the drainage layout.

1.5 Construction details must be provided on drawings for all drainage systems. These drawings must show plan, profiles, cross sectional views, base lines and offsets.

1.6 When calculating required storage capacity of the retention/detention facilities, use only the expected runoff of the design storm for the total area of the development site, unless otherwise required by the Department of Public Works.

1.7 A simple retention/detention design method, such as the "Yrjanainen and Warren Method," may be used for areas less than 200 acres. For areas exceeding 200 acres, the Soil Conservation Service's Method or similar type analysis must be used.

1.8 The size of the controlled outlet shall be calculated for the total drainage basin when the total runoff from both off-site and on-site are combined.

1.9 All structures shall be located no closer than 10 feet from the spring line of any culvert and 15 feet from the top of any channel bank. These setbacks must be shown on the plans. (See Figure 1)

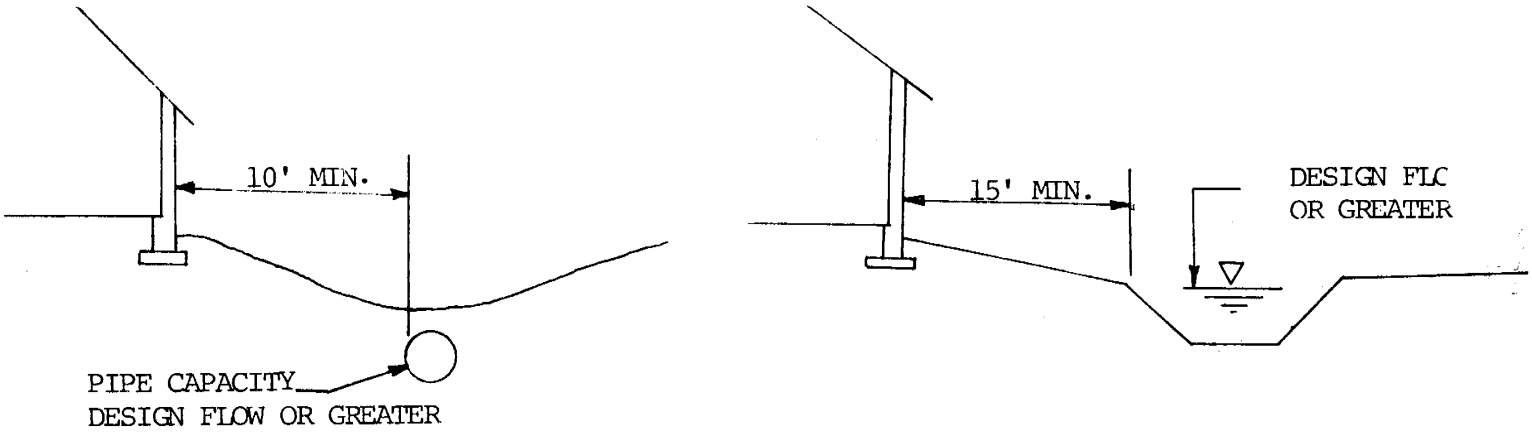


FIGURE 1

1.10 Permanent bridges that provide minor stream crossings for residential access streets shall be designed to accommodate the 25 year frequency flood with a minimum of 2 feet of clearance between the maximum design water surface and the lowest portion of the bridge span. A minimum clearance of 6 feet above the 100 year frequency maximum water surface must be provided for any major stream or river unless otherwise approved by the Department of Public Works.

1.11 An emergency overflow system is required for all retention/detention facilities.

1.12 Open retention/detention ponds and infiltration facilities shall not be located in dedicated public road right of way areas.

1.13 Sharp edge circular orifices may be used for discharge restriction where $Q = Ac\sqrt{2gh}$ and "C" = 0.62. "h" shall be the vertical distance between maximum water surface and centerline of the orifice for other than submerged outlets. See Handbook of Hydraulics, Fifth Edition, by King and Brater for other acceptable types of orifices.

1.14 Where a natural ground depression occurs in the drainage course of an area to be considered in contributing runoff in the natural state to a proposed retention/detention facility, consideration shall be given to past detention capability of that natural depression which has caused an increase in Time of Concentration. The following procedure may be followed in determining the time of flow in the depression: From a topographical map of the depression determine the mean depth and width and calculate the area. Determine the rate of runoff in the natural state to the depression and the corresponding time of concentration from Q=AV, calculated the mean velocity through the depression. Determine the length of depression and calculated time of flow. Add this time of flow to time of concentration at head of the depression to determine time of concentration at the downstream end thereof. Also, the existing retention/detention capacity of the natural depression must be analyzed in calculating the allowable rate of runoff from the subject property.

1.15 Where the drainage area upstream of a proposed retention/detention facility exceeds 200 acres, determine Time of Concentration to the detention facility for the immediate upstream 200 acres of the drainage area, including the development, contributing runoff to the detention pond and calculate runoff using the Rational Formula, Q=ACI. Then, determine time of concentration for entire drainage basin upstream of the detention pond and calculate runoff to the pond using Rational Formula. Use the greater of the two calculated runoff in determining the runoff to the pond in the natural state. Follow the same procedure for designing the most upstream culvert receiving runoff from the upstream basin.

1.16 The limits of the 25 or 100 year frequency flood plains (25 Stream)(100 River) may be required to be delinated on the face of the Final Plat, as well as the engineering drawings for plat construction.

1.17 Arrows indicating drainage direction in all public and private property shall be shown on the Construction Drawings for all hydraulic conveyance systems.

1.18 A soils report prepared by an engineer may be required when a proposed development is adjacent to a steep hillside.

1.19 A topography map, at least 1" = 100', shall be used to indicate drainage areas contributing runoff within the proposed development.

1.20 The best topographical map sufficient in area to show all areas draining onto the proposed land development must be submitted and show enough of abutting downstream properties to indicate natural or man-made drainage course into which the proposed land development is to drain. This map shall have indicated thereon direction of flow, acreage of areas contributing drainage to the development, the outline of the development, the length of travel and grade of the mean drainage course in upstream areas from the farthest upstream point in the upstream area to the farthest upstream end of a proposed storm sewer or ditch in the development and to any proposed storm water retention/detention facility. Said map shall have references shown thereon for use and reference in the expository part of drainage plan.

1.21 Pipe anchors may be required for steep pipe slopes or when constructed in unstable soils regardless of whether it is a buried or above ground installation unless proven stable by a soils analysis.

1.22 All disturbed areas shall be hydroseeded unless approved by the King County Department of Public Works. The grass must be established prior to final plat approval.

SECTION 2 - DEFINITIONS OF TERMS

2.1 Design storm is the rain storm of a chosen intensity and duration selected for a storm drainage analysis and system design, and can be expressed as having a statistical probability of recurrence, i.e. once in every 5, 10, 25, or 100 years.

2.2 Drainage area is the area that contributes runoff to the point under design.

2.3 Embankment (or fill) is a bank of earth, rock or other material constructed above the natural ground surface.

2.4 Flowline or Invert means that part of a pipe or culvert below the spring line - generally the lowest point of the internal cross section.

2.5 Height of Cover (hc) is the distance from the crown of a culvert or conduit to the finished ground or road surface.

2.6 Impervious means impenetrable. Completely resisting the entrance of liquids.

2.7 Intercepting Drain is a ditch or trench filled with pervious filter material around a subdrainage pipe.

2.8 Revetment is a wall or a facing of stone placed on stream banks to prevent erosion.

2.9 Right Bank is that bank of a stream which is on the right when one looks downstream.

2.10 Spring Line (or springing line) is the line of intersection between the intrados and the supports of an arch. Also the maximum horizontal dimension of a culvert or conduit.

2.11 Subdrain (underdrain) means a pervious backfilled trench containing a pipe with perforations or open joints for the purposes intercepting ground water or seepage.

2.12 Top of Bank shall mean a major topographic break as approved by the Department of Public Works.

SECTION 3 - TEMPORARY EROSION/SEDIMENTATION CONTROL

3.1 A Temporary Erosion/Sedimentation Control Plan (TESCP) is required unless otherwise approved by the Department of Public Works.

3.2 Prior to the initial clearing and grading of any land development, provisions shall be made for the interception of all potential silt-laden runoff that could result from said clearing and grading. Said interception shall preclude any silt-laden runoff from discharging from the proposed land development to downstream properties unless approved as hereinafter described. Said interception shall cause all silt-laden runoff to be conveyed by open ditch or other means to whatever temporary facility is necessary to remove silt from said silt-laden runoff prior to discharge to downstream properties.

3.3 The TESCP should provide erosion-sedimentation control during the following three phases of construction: (a) Before construction (prior to excavation), (b) During construction (during excavation), and (c) After construction (until the site is stabilized).

3.4 Prior to initial clearing and grading of construction site, an evaluation of the following factors must be carried out:

a. Rainfall and Runoff - The amount of rainfall and runoff needs to be analyzed to determine appropriate erosion-sedimentation control measures. Erosion potential increases greatly during the October-May rainy season. However, in King County severe rains can occur during any month.

✳ b. Soil Erodibility - Soils should be identified as to their erosion potential. Soils having erosion potential from slight to very severe will need greater erosion-sedimentation control measure than areas with slight erosion. Table 1 outlines soil series having slight to severe erosion potential. The approximate locations of these soils are shown on King County Soil Survey Maps developed in 1973. These maps are available for your use at King County and the King County Conservation District Office.

c. Slope and Runoff - Denuded ground will require some form of erosion protection.

d. Cover - Erosion protection will be required for all disturbed areas.

TABLE 1

SOIL	GROUND WATER INFILTRATION POTENTIAL	EROSION POTENTIAL	BUILDING FOUNDATION LIMITATION*
AgB	Low	Slight	Moderate
AgC	Low	Moderate	Moderate
AgD	Low	Severe	Severe
AkF	Low	Very Severe	Severe
AmB	Low	Slight	Moderate
AmC	Low	Moderate to Severe	Moderate
An	High	Slight	None to Slight
BeC	Moderate	Moderate	Moderate to Severe
BeD	Moderate	Severe	Severe
BeF	Moderate	Very Severe	Severe
Bh	Low	Slight	Severe
Br	Moderate	Slight	Severe
Bu	Moderate	Slight	Severe
Cb	High	Slight	Severe
Ea	Low	Slight	Severe
Ed	Moderate	Slight	Severe
EvB	High	Slight	None to Slight
EvC	High	Moderate	Slight to Moderate
EvD	High	Severe	Severe
EwC	**	Moderate	Slight to Moderate
InA	High	Slight	None to Slight
InC	High	Moderate	Slight to Moderate
InD	High	Severe	Severe
KpB	Low	Slight	Moderate
KpC	Low	Moderate	Severe
KpD	Low	Severe	Severe
KsC	High	Moderate	Slight to Moderate
Ma	**	Slight	Severe
NeC	High	Slight	Slight to Moderate
Ng	Moderate	Slight	Severe
Nk	Moderate	Slight	Severe
No	Moderate	Slight	Severe
Ör	Low	Slight	Severe
Os	Low	Slight	Severe
OvC	Low	Moderate	Moderate to Severe
OvD	Low	Severe	Severe
OvF	Low	Very Severe	Severe
Pc	High	Slight	Severe
Pk	High	Slight	Severe
Pu	Low	Slight	Severe
Py	Moderate	Slight	Severe
RaC	Moderate	Moderate	Slight to Moderate
RaD	Moderate	Severe	Severe
Re	Low	Slight	Severe
Rh	High	Slight	Severe
Sa	Moderate	Slight	Severe
Sh	Low	Slight	Severe
Sk	Low	Slight	Severe
Sm	Low	Slight	Severe
Sn	Low	Slight	Severe
Sr	Low	Slight	Severe
Su	Moderate	Slight	Severe
Tu	Low	Slight	Severe
Ur	**	Slight	Variable
Wo	Low	Slight	Severe
RdC	High	Moderate	Slight to Moderate
RdE	High	Severe	Severe
So	High	Slight	Severe

*SCS rating of soils for single family dwelling foundations for 3-story buildings or less.

**So widely variable that classification is not precise.

5/79

3.5 During the TESCP design stages certain potential water problems that should be considered include:

a. Disturbance of ground water tables.
b. Construction on or near potential landslide areas and extent of vegetation removal necessary.
c. Installation of adequate stream crossing structures where stream fordings are necessary.
d. Encroachments on stream flow by landfills, culverts, dikes and buildings.
e. Influences of increased stormwater runoff as imposed by cleared surface areas and of impervious streets, parking lots, and buildings.
f. Changes in drainage areas caused by diversions and gradings.
g. Development of on-site borrow pits.
h. Flood plain excavation work.
i. Stream channel improvement.
j. Disposal of petroleum wastes, pesticides, cement washings, and other checmicals.
k. Construction of access and haul roads.
1. Nearness of the construction site to streams, lakes and other vulnerable areas.

3.6 The TESCP for a proposed construction site should delinate areas to be cleared and graded, identify cut and fill areas and show in detail the desilting facilities, intercepter ditches (channels), the maximum velocities, velocity check dams, soils, topography, vegetation and re-seeding practices, and anticipated construction period.

3.7 Sediment Basin - Site should be selected to provide adequate storage for approximately 0.5 inches per acre of drainage area. Trap or pipe spillway crest (if there is no emergency spillway). Combined capacity of the pipe and emergency spillway must be designed to handle a ten-year frequency storm. The embankment must have a minimum top width of six feet. Side slopes must be no steeper than 3:1, and the maximum fill height must be four feet, including one foot of freeboard, unless proven adequate by a soils consultant. Hydro-mulch or equivalent seeding of embankments will be required to minimize erosion. Temporary fencing of sediment storage areas will be required when dead storage exceeds 0.5 feet unless approved by the King County Department of Public Works. See Figure 1, page 47 for a typical sedimentation basin.

3.8 Check dams shall be employed or some other acceptable method to limit ditch velocities to 5-foot per second unless rocked. "V" ditches may be used with side slopes no steeper than 2 horizontal to 1 vertical.

3.9 It is recommended wherever possible to locate intercepting ditches across future building sites to preserve natural vegetation. Intercepting ditches outside of future building sites should meander to avoid trees.

3.10 Cut-off trenches are recommended to dissipate drainage into the natural on-site vegetation. However, drainage from disturbed areas must be directed into a siltation pond prior to leaving the site unless otherwise approved by the Department of Public Works.

3.11 Temporary/permanent hydroseeding or acceptable seeding and mulching must be provided whenever perrenial cover cannot be established on sites which will be exposed for 60 days or more. See Storm Water Management Practices for information on seeding and fertilizer.

3.12 Different erosion prevention methods are discussed in Section II of the Stormwater Management Manual. A copy of this Section is available in King County Hydraulics Division. Also some Best Management Practices are discussed in detail in the report titled "Construction and Water Quality. A Guide to Recommended Construction Practices for the Control of Erosion and Sedimentation in King County". This report is available from Metro.

Ponds may be sized at 150 cu-ft per acre of runoff providing:

a. Check-dams are placed within the temporary ditches and spaced so as to keep the ditch velocity at zero. Check-dams should be constructed with 3/4" fractured rock or larger (up to 1½").

b. A standpipe w/2 drilled holes and surrounded w/gravel is provided as an outlet to the pond. The 2 holes must be sized to allow only 10% of the Qexist to discharge from the pond.

Ponds may be sized at 150 cu-ft per acre of runoff providing:

a. An acceptable filtration system is installed at the outlet of the pond. One acceptable method calls for a mirafy sheet/fence embedded within a gravel berm around the standpipe w/2 holes sized as above.

SECTION 4 - NATURAL & CONSTRUCTED CHANNELS -- REQUIREMENTS

4.1 Bank stabilization is required when the design flow velocities of constructed channels exceed 5 feet per second (5 fps).

4.2 Unstable river and major stream banks in proposed subdivisions shall be stabilized to the satisfaction of Department of Public Works.

4.3 Show design velocities in computations for all constructed drainage ditches.

4.4 All road ditches shall be as shown on King County Standard Road Section for Open Ditch Construction. All other ditches or grassed channels shall have maximum side slopes of 3 or 2 horizontal to 1 vertical if stabilized with rock riprap unless approved by the Department of Public Works. Ditches may be "V" shaped or trapezoidal.

4.5 Capacity of ditches and channels shall be determined by the Manning Formula. The value for "n" shall be 0.030 for natural earth-lined ditches. The value for "n" shall be 0.035 for ditches with rock-lined bottoms. Minimum velocity for ditch at design flow shall be 2.0 feet per second unless approved otherwise by the Department of Public Works.

4.6 Ditches shall have rock-lined bottoms and side slopes at discharge point of storm sewers or culverts. The rock blanket shall have a minimum thickness of 12-inches and extend for a minimum of 8 feet downstream from the end of the storm sewer or culvert.

4.7 All ditch sides and bottoms shall be seeded except, of course, rock-lined channels and roadside ditches.

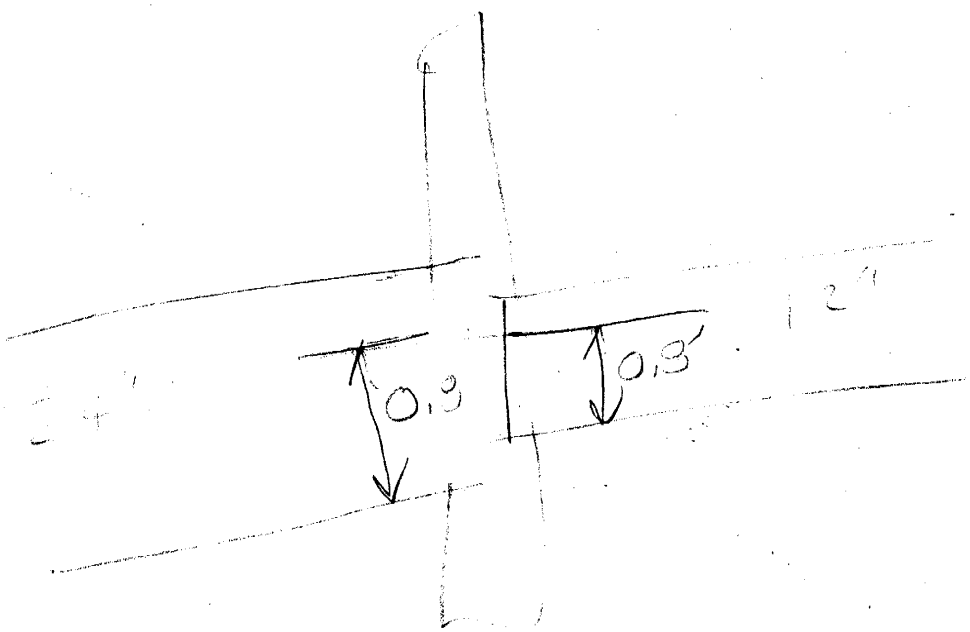
4.8 The channels at points of discharge from culverts and storm sewers with slopes 15% or greater shall be rock-lined with boulders with one face a minimum of 24" in dimension. Said rock lining shall extend for a distance of 10 feet minimum from the point of culvert or storm sewer discharge and shall have a width 3 feet in excess of the diameter of the culvert or storm sewer. Also, a special outlet structure serving as an energy dissipator may be required.

4.9 For normal rock lined ditches with design velocities less than 8 feet per second, querry rock should be used as defined in Section 9.13.1 of Washington State Highway Standard Specifications. Also, the minimum rock thickness shall be 12 inches.

4.10 Where velocity of flow in road ditches exceeds 5.0 feet per second the two sides of the "V" ditch shall be lined with rock as specified in (4.9) above to a minimum depth of 12". Top of rock lining shall extend to the bottom of the shoulder crushed rock.

4.11 Ditches and channels in property other than public property will require a drainage easement sufficient in width to accommodate a 15 foot wide access along each side of the channel when the channel top width exceeds 30 feet and the design flow is greater than 10 cfs. When the channel top width is 30 feet or less and the design flow is greater than 10 cfs, a 15 foot wide strip for an access road will be required on only one side.

4.12 All ditches shall be designed with a minimum freeboard of 0.5 feet when the design discharge is 10 cfs or less and 1 foot when the design discharge is greater than 10 cfs.



SECTION 5 - CLOSED SYSTEMS & STRUCTURES -- REQUIREMENTS

5.1 The maximum allowable velocity in concrete pipe is thirty (30) feet per second.

5.2 A minimum velocity in any pipe or culvert carrying the design storm flow shall be three (3) feet per second. EXCEPTIONS: Culvert installed as "equalizers" and those culverts and piping that are a direct part of the retention/detention system.

5.3 Show design velocities in computations for all storm water culverts.

5.4 Debris barriers shall be required at the inlets of all culverts larger than 24". Debris barriers may be required for culverts less than 24".

5.5 Match crowns of culverts or use the 0.8 rule at all catch basins and manholes, except for drop manholes, or unless otherwise approved by the Department of Public Works. The 0.8 rule matches 0.8 the diameter of the culverts instead of culvert crowns as measured from their respective inverts.

5.6 Downsizing of culverts within a closed system with culverts 18 inches in diameter and smaller is not permitted. Culverts larger than 18 inches in diameter may be downsized 3 inches, if the culvert capacity is adequate and a minimum 100 foot run of pipe is proposed to be downsized.

5.7 Storm water entering a closed storm drainage systems shall be via catch basins as shown on King County Standards for debris and silt removal.

5.8 A 8-inch pipe laid with a minimum slope of 2 percent may be used to connect a curb inlet to a catch basin if the length of the pipe does not exceed 44 feet. If a longer pipe is required to connect a curb inlet to a catch basin, a catch basin shall be used in lieu of the curb inlet and a 12" pipe shall be used with a minimum velocity of 3.0 fps at design flow. Use min 12"ϕ pipe on County R/W when going from ditch to ditch. Use min 12"ϕ pipe for [illegible] system.

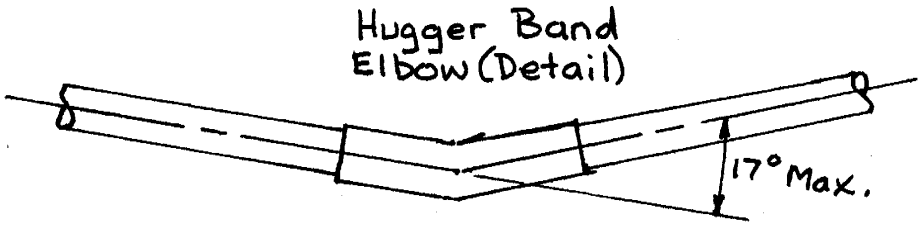
5.9 Any closed storm sewer system collecting runoff from paved areas in public or private property shall provide for oil separation prior to discharge of the system to any offsite hydraulic conveyance system unless otherwise approved by the Department of Public Works.

5.10 Type II catch basins or larger shall be required to accommodate all pipe greater than 18" in diameter.

5.11 No storm sewer between catch basins or manholes shall be less than 12" in diameter.

5.12 Where any pipe discharges onto an area at a point other than a natural defined drainage course, the discharge shall be dispersed over an area sufficiant to approximate the predeveloped condition.

5.13 No storm sewer pipe in a drainage easement shall have its centerline closer to a private rear or side property line than 5'.



SECTION 6 - OPEN RETENTION/DETENTION PONDS - REQUIREMENTS

6.1 Side slopes for earth lined retention/detention ponds shall be no steeper than 3 horizontal to 1 vertical unless approved by the Department of Public Works. Flatter slopes are encouraged.

6.2 The access road grade into the proposed retention/detention pond must be no steeper than 6 horizontal to 1 vertical.

6.3 All retention/detention ponds not abutting a public right of way shall be accessible to King County Work Forces for maintenance and operation. Access shall be provided in access easements and shall accommodate vehicular traffic. Access shall be surfaced with a 14-foot wide gravel, Class "B" or equal lane laid at a minimum depth of 6" or other surface approved by the Department of Public Works. Well graded quarry rock may be used with 6" maximum, 1-1/2" minimum aggregate. Access surfacing must accommodate traffic loading of 10 cubic yard dump truck and 3 cubic yard front end loader. A gravel road may be seeded but no topsoil added.

6.4 A vehicular access road must be provided to the bottom of the retention/detention pond when the bottom width of the pond is 20 feet, or greater, and the road shall be surfaced with quarry rock to a minimum depth of 6". Gravel base, class "B" may be required pending soil conditions. The access road shall be able to support maintenance vehicles and equipment such as a 10 cubic yard dump truck and 3 cubic yard front end loader.

6.5 All retention/detention ponds shall have a minimum of one foot of freeboard above the maximum design water surface.

6.6 Any embankment for a retention/detention pond in excess of 4 feet must be approved by a qualified engineer and the Department of Public Works. The minimum top width of this berm shall be 15 feet with a key section, unless otherwise approved by a qualified engineer and the Department of Public Works.

6.7 Any embankment less than 4 feet including 1 foot of freeboard in depth forming one or more sides of a retention/detention pond shall have a minimum 6 foot wide berm with back slope not to exceed 2 horizontal to 1 vertical.

6.8 All constructed and graded retention/detention ponds shall be sloped no flatter than 0.02 ft./ft. (2%) towards the outlet, for drainage.

EXCEPTION: This requirement need not apply to natural ponds, which exist, and are utilized for storm water detention.

6.9 All berms or embankments constructed for retention/detention ponds in excess of 2 feet in height shall be compacted to at least 95 percent of the maximum relative density as determined by Section 2-03.3(14)D of the Washington State Highway Department 1976 Standard Specifications. Those berms 2 feet in height and less shall be compacted as stated above or compacted by a dozer or similar type piece of equipment in lifts not to exceed 6 inches of compactable soil.

6.10 The back slopes for all earth berms shall be no steeper than 2 horizontal 1 vertical.

6.11 Backup retention/detention facilities and the preservation of natural drainage ponds are encouraged. See figure 2 below.

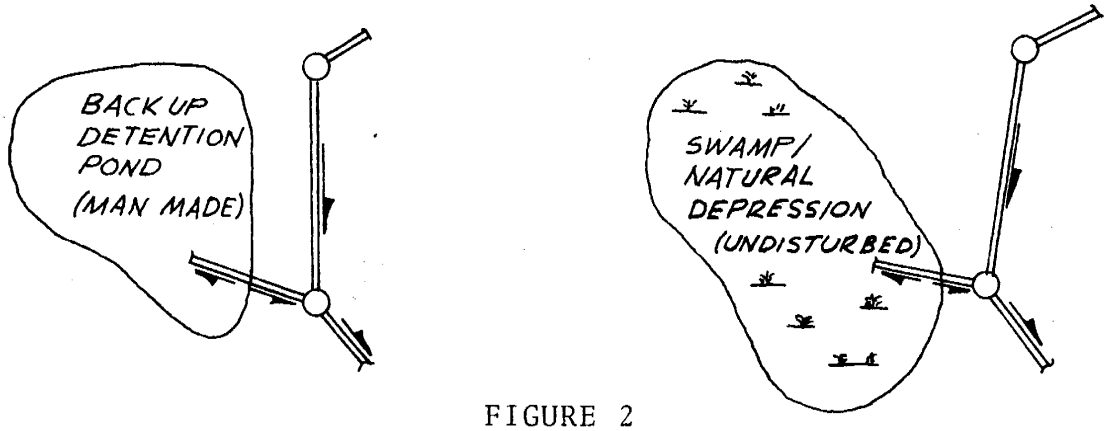


FIGURE 2

6.12 All detention ponds shall have a spillway whose subgrade elevation shall equal or be greater than the maximum design water surface elevation.

6.13 Spillway surfacing may be rock spalls or crushed rock having one face with a minimum dimension of 4 inches. Spalls or crushed rock shall be laid in two or more layers to a minimum depth of 6 inches. Spillway shall have side slopes at the ends not to exceed a slope of 3 horizontal to 1 vertical.

6.14 Spillways for retention/detention ponds shall be designed as suppressed sharp-crested weirs so long as maximum depth of flow over weir does not exceed 0.33 feet (4") unless approved by the Department of Public Works.

6.15 Storm retention/detention ponds may be utilized as Interim Drainage Facilities if approved by the Department of Public Works.

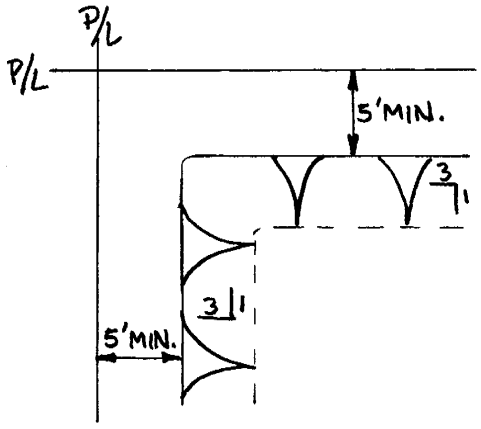
6.16 The use of a private parking lot to act as a retention/detention facility in other than residential developments is permissable provided the surface storage portion of the facility is located entirely within the parking portion of the lot. The access and service roads shall not be utilized for surface storage.

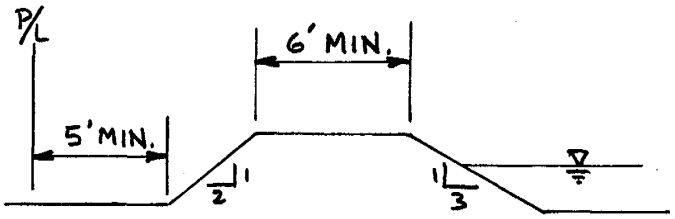
6.17 A fence may be required around a retention/detention pond where the pond side slopes are steeper than 3 horizontal to 1 vertical.

6.18 All retention/detention pond side slopes need to be stabilized with grass except where rocked or otherwise stabilized to the satisfaction of King County Hydraulics Division.

6.19 A detention pond acting as a dam must be adequately designed by a Registered Professional Engineer qualified in soils and foundation engineering and dam design. The design must be done prior to commencement of construction of the pond/dam. The above professional engineer must submit design data with a letter stating that the design is adequate. The plans must be stamped and signed by said engineer. Upon completion of the pond/dam the above engineer must submit a letter stating that the pond/dam was constructed according to his design and specifications.

6.20 When detention facilities are proposed in required open space, approval from the Building & Land Development Division is required prior to submittal of the final plan/profile to the Division of Hydraulics.





SECTION 7 - CLOSED DETENTION SYSTEMS

7.1 A standard manhole or Type II catch basin is required when the depth exceeds 5 feet from the flowline (invert) of a culvert to the top of grate. A ladder or steps are required when the depth exceeds 3 feet from the flowline (invert) to the top of grate excluding Type 1B catch basin.

7.2 Adequate access to detention facilities shall be required, i.e. a manhole at each end of a closed, underground facility. See figures 5 and 6.

7.3 All steel tanks, culverts, pipes and other steel parts of any storm drainage system shall be galvanized and have a treatment 1 asphalt coating or better as specified in the 1977 Washington State Highway Department Standard Specifications. Aluminum and concrete pipes and structures do not require a treatment 1 coating. All pipes and structures must be structurally sound.

7.4 Flow restrictor catch basins must have solid round locking lids marked "Drain".

7.5 All detention catch basins must have solid round locking lids marked "Drain".

7.6 A plan view of the restrictor catch basin must be submitted as part of the drainage plan. The plan view must show location of steps and pipe.

SECTION 8 - INFILTRATION SYSTEMS

8.1 If an infiltration system is used, runoff is required to flow through an oil separator and a filtering system prior to entering the infiltration system unless otherwise approved by the Department of Public Works.

8.2 No soils infiltration shall be assumed in detention ponds or channels, unless otherwise approved by the Department of Public Works.

8.3 French drains and dry wells generally are not recommended as a means of disposing of surface water, except for small areas and areas that have a high infiltration rate. Also, they will only be approved when the engineer shows that an adequate filtering device is to be provided giving special note to the capacity of the filtering device to pass water into the French drain or drywell.

8.4 If an infiltration system is used, a percolation test or tests must be provided showing percolation rates in minutes per inch.

8.5 The minimum percolation rate for any infiltration system is 15 min/in. See table 7 on page 24 for typical drywell structures for various percolation rates. Percolation rates must be performed by a registered Civil Engineer or a registered Sanitarian, or a person holding a valid Sewage Disposal System Designers Certificate of Competency.

8.6 Table 7 may be used for sizing drywell structures in short subdivisions for individual houses where the road surfaces including driveways are less than 5,000 square feet and there is no offsite drainage. If table 7 is followed, an engineer's stamp is not required for the design of the infiltration system.

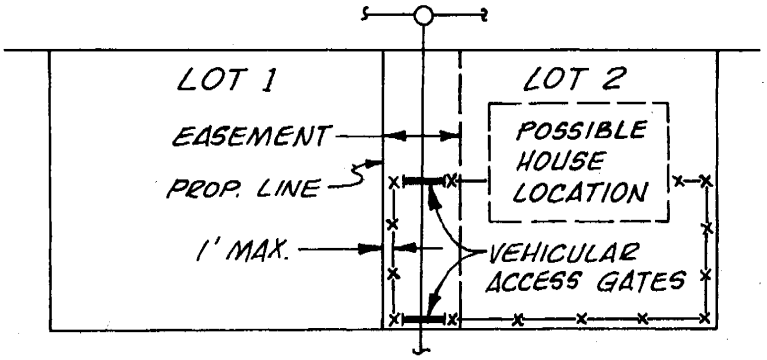
SECTION 9 - RIGHTS OF WAY & EASEMENTS -- REQUIREMENTS

9.1 All retention/detention ponds required pursuant to Ordinance No. 2281 (as amended) may be required to be located in separate tracts with a drainage easement for maintenance. If the tract is not adjacent to a roadway, a fourteen (14) foot wide roadway, surfaced with at least 6 inches of Class "B" gravel or equal will be required within an easement for unobstructed ingress and egress between the tract and the public roadway.

9.2 When platting or developing an area adjacent to a river, the applicant shall provide a 30 foot wide Flood Control Maintenance Easement to King County Department of Public Works. This easement is measured landward from the top of the river bank. See paragraph 2.12.

9.3 The written restriction shall be added to the final plat drawing that "Prior approval must be obtained from the Department of Public Works before any structures, fill or obstructions, including fences, are located within any drainage easement or delineated flood plain area."

An example of an acceptable fencing plan is shown below:



9.4 An access gate for access roads is required and shall be structurally and aesthetically acceptable for the use and location proposed or an acceptable alternative to control traffic. Removable posts spaced at a maximum 4 foot centers is an acceptable access gate where fencing is not required.

9.5 A minimum 15 foot wide drainage easement is required for all closed storm drainage systems that contain storm drains having a diameter of five (5) feet, or more.

9.6 All public and maintained storm water drainage systems including collection, conveyance and restrictions shall be located in drainage easements to King County Department of Public Works except commercial developments where the design flow is less then 10 cfs. All drainage easements shall be shown on the Final Construction Plans and Plat.

9.7 Permanent access and drainage easements shall be granted to King County for any storm water retention/detention facility and an access road to that facility where such facility and access road are located on property other than the proposed land development but serve the development. The owner in fee simple and the contract purchaser of the property upon which the access road and facility are to be located shall execute the said easement. King County shall have the option to record the easement or delay its recording for any length of time it deems justifiable, depending upon any extenuating circumstances.

SECTION 10 - STANDARDS FOR PLAT SUBMITTALS

10.1 An overall storm drainage plan must be shown on a single sheet when the storm drainage plan and profile sheets exceed 3.

10.2 When plans are returned to the applicant or his consultant for corrections, any changes by the consultant must be marked on a print in color and returned. The date of these changes must be indicated and the color used for marking changes cannot be red or yellow.

10.3 To help expedite the review of a development, the applicant or his consultant may request a special meeting with the Department of Public Works following his receipt of our initial comments. However, before this meeting, the applicant and his consultant should review all initial comments and have a solution to propose. This meeting will be used to review the overall concept of the plan and any modification and not computations.

10.4 The consultant must demonstrate to the satisfaction of the Department of Public Works any deviation from the design criteria discussed in this handbook.

King County Department of Public Works

Surface Water Management Division

Special Information Bulletin

Subject: A NEW SERVICE **No.** 1

Effective Date: APRIL 1, 1982

WHAT AND WHY - A means to announce changes in Surface Water Management policies, standards, procedures and other matters of interest and concern.

HOW AND WHO - These Bulletins will be distributed by the Surface Water Management Division as follows:

- At Building and Land Development Division desk, Surface Water Management Division and Public Works Map Counter
- To the Seattle Master Builders
- To the Washington Council of Civil Engineers and Land Surveyors
- To the Land Surveyors of Washington, Puget Sound Chapter
- To the Utility Contractors Association of Washington
- To all Hydraulics Manual recipients
- To all individuals and organizations who have indicated a desire to be on the Surface Water Management Division mailing list
- In selected correspondence to Permit applicants or their agents
- To other County offices as applicable

WHEN - As necessary

Anyone interested in receiving this Bulletin regularly should contact the Surface Water Management Division, Room 976 King County Administration Building, 5th & James, Seattle, WA 98104.

For further information, Call 344-2585

King County, Washington
Randy Revelle, King County Executive

Department of Public Works
James W. Guenther, Director

Surface Water Management Division
David A. Aggerholm, Manager
976 King County Administration Building
Seattle, Washington 98104

King County Department of Public Works

Surface Water Management Division

Special Information Bulletin

Subject: SUPPLEMENTAL DRAINAGE PLAN INFORMATION REQUIREMENTS **No.** 2

Effective Date: APRIL 1, 1982

This Bulletin outlines requirements for information which must be included with all detailed drainage plans for subdivisions, short subdivisions and commercial developments submitted to the Surface Water Management Division for the first time on or after the effective date of this Bulletin.

Any questions should be referred to the Development Review Section at 344-3874.

For further information, Call 344-2585

King County, Washington
Randy Revelle, King County Executive

Department of Public Works
James W. Guenther, Director

Surface Water Management Division
David A. Aggerholm, Manager
976 King County Administration Building
Seattle, Washington 98104

SPECIAL INFORMATION
BULLETIN No. 2
Effective April 1, 1982

KING COUNTY DEPARTMENT OF PUBLIC WORKS

SURFACE WATER MANAGEMENT DIVISION

SUPPLEMENTAL DRAINAGE PLAN INFORMATION REQUIREMENTS

Item	What We Want	Why We Want It
1. Detailed ground surface elevations (based on actual plan survey rather than aerial topography or random spot elevations) for all outlets and discharge points and for pond areas. This may require extensive downstream data if a steep slope is involved.	Detailed topography maps of proposed pond areas, outlets and discharge areas. The map shall indicate contours at one foot intervals based on actual plane survey, and shall extend for at least 15 feet outside of the proposed limits of cut and fill for the pond area. Ground surface spot elevations shall be shown for at least 50 feet downstream and in a reasonable fan of all discharge points.	Many outlet structures have been built according to design; however, due to actual ground elevations, the outlet won't work as designed. For example, (1) the outlet dispersion trench of one R/D facility would not drain to adjacent property because the adjacent property was 1 foot higher than the plan indicated, causing 1 foot of standing water in the R/D facility. Not only did a loss of storage result, but the basketball court in the bottom of the facility was always covered with at least 1 foot of water (excessively deep for basketball and not deep enough for water polo); (2) a dispersion trench was installed at the top of a 3/4 horizontal to 1 vertical downslope. The dispersed water collected and caused extensive erosion damage down the 200 foot slope. In reviewing the plan, the design engineer had identified the slope as 3 horizontal to 1 vertical; (3) an outlet dumps into a stream. During the rainy season, the stream raises approximately 9 inches, backing water into the underground storage tank causing a loss of storage; (4) an outlet pipe discharges flows on a steep slope directly into the base of a large predominate fir tree causing an undermining and loss of stability.
2. Trees and other predominant physical features in pond areas.	Locate and identify all trees, rock outcrops and existing structures within the limits of clearing which are to be saved. Trees are to be identified by type, diameter, and height. Verify all "saved" features will survive the construction process and anticipated water and silt flooding.	Minimize field change requests caused by developers wanting to save large trees which were not identified during design review. Also, some trees have been damaged by the construction of a pond or the roots are flooded causing the trees to die. These dead trees can blow over onto adjacent properties causing County liability and/or extra maintenance costs.
3. Detailed information regarding swamps, wetlands, floodplains, channels, existing storm drainage system, and tops of banks (may include a plan, profile and cross-sections).	Detailed topographic information consisting of sufficient spot elevations to delineate the perimeter and depth of the feature and/or one foot contour interval for all swamps, wetlands, flood plains, channels, swales, streams and existing storm drainage system to be provided for the entire property.	These features contribute significantly to the total peak flow reduction. If these features are not identified and analyzed by the design engineer, the allowable release rates do not comply with King County ordinance. The after-development flows are considerably higher than the pre-development flows and cause downstream damages. This increases County maintenance costs and liability.
4. Verification of the area contributing to the development and location of off-site drainage features.	A detailed investigation and identification of the drainage basin contributing to the proposed development. This may require field checking all of the existing upstream drainage features to adequately outline the drainage basin or a thorough search and analysis of the designs and plans for existing upstream facilities. A verification by the design engineer of the drainage basin depicted in the drainage calculations is based on an actual field investigation.	In some instances, the upstream drainage basin has not included all of the contributing drainage area, which has led to inadequate design and serious and costly problems.
5. An evaluation of downstream conditions and the effects of the development on downstream drainage features.	Investigate and identify all downstream features for a minimum of one-quarter mile, in other words channels, pipes, flood plains, swamps, wetlands, swales. Analyze the potential impacts, i.e., erosion, sedimentation, flooding, water quality, low flow, water rights, on all of these downstream features as a result of the development. In basins for which King County has developed "basin studies" or has identified as critical/sensitive areas, this information may be available from Surface Water Management Division.	King County ordinances require the installation of facilities to limit the peak rate of runoff, but the total volume of water entering the drainage system will be increased. Many of the present drainage systems will not accommodate the extra volume of runoff. Due to the change in individual runoff hydrographs from all of the developments within a drainage basin, the total hydrograph for the basin can change drastically. This total change causes erosion, flooding and water quality degradation. In addition, the lack of groundwater recharge can adversely affect low flows and existing water rights.

SPECIAL INFORMATION
BULLETIN No. 2
Effective April 1, 1982

KING COUNTY DEPARTMENT OF PUBLIC WORKS

SURFACE WATER MANAGEMENT DIVISION

SUPPLEMENTAL DRAINAGE PLAN INFORMATION REQUIREMENTS

Item	What We Want	Why We Want It
6. Soil types, potential for erosion from the subject property and a certification that the outlet structure has been designed based on an evaluation of the existing soil type.	An identification of the various soil types encountered on the site and the potential for erosion in roadside ditches, channels, other water courses and all discharge points. The outlet improvements or treatment must be compatible with soil type, velocity of water and slope. The design engineer must verify the erosion control treatment will effectively stabilize these facilities (ditches, water courses, channels and discharge points) and is based on an evaluation of the soil, velocity and quantity of water, slope and any other factors which may contribute to the erodability.	Nearly all roadside ditches, channels, outlets from discharge points, are inadequately protected from erosion. More total volume, higher discharge during smaller rainfalls and the flows being concentrated at one point, all contribute to greater erosion at the discharge area. The purpose of the data is to minimize erosion and resultant sedimentation of retention-detention facilities and other drainage features, and protect adjacent properties from erosion and sedimentation.
7. Contributing drainage areas.	The limits of drainage basins contributing to retention-detention facilities delineated on a map. Identify both contributing area and "bypass" area.	Retention-detention, facilities are designed to accommodate specific areas. The orifice sizes, riser heights and storage volumes are critically related to the area contributing to the facility. However, during the development construction, the contributing area is modified, thereby changing the effectiveness of the facility. By delineating the area, the inspector can check the area and determine if the design of the retention-detention facility should be revised.

King County Department of Public Works

Surface Water Management Division

Special Information Bulletin

THESE GUIDELINES ARE EFFECTIVE SEPTEMBER 1, 1985 FOR FIRST SUBMITTALS.

Subject: STORM DRAINAGE CONTROL - REQUIREMENTS AND GUIDELINES
(DESIGN REVISION: MULTIPLE ORIFICES)

This bulletin outlines requirements, guidelines and design criteria for a change to "Storm Drainage Control - Requirements and Guidelines, King County Department of Public Works, Division of Hydraulics, May 1979". Figure 1, page 46 -- "Flow Restrictor/Oil Separator, Control Devise/Catch Basin" is replaced by "Multiple Restrictor/Oil Pollution (FROP) Control Device".

These requirements will apply to all new projects submitted for review after the effective date of this bulletin.

DESIGN CRITERIA FOR USE OF MULTIPLE RESTRICTOR/OIL POLLUTION (FROP) CONTROL DEVICE

(1) Multiple orifices are required when the allowable release rate produces an single orifice greater than 2 ¼ inch diameter or a flow greater than 0.30 cfs.

(2) When multiple orifices are required, a minimum of 2 orifices are required and 3 orifices are recommended depending on orifice sizes, discharge and head available.

(3) The minimum orifice diameter is 0.5 inches.

(4) The allowable discharge shall be divided equally among the orifices at maximum head. For example, when 2 orifices are used, each orifice shall pass 50% of the allowable Q under maximum head; and, when 3 orifices are used, each orifice shall be sized to pass 33% of the allowable Q under maximum head.

(5) The minimum vertical spacing between orifices shall be 1.0 feet (See attached FROP Section detail.)

(6) A plan and cross-section (to scale) detail must be provided for all multiple orifices (FROP) devices.

(7) The simplified Rational Method can be used for determining the allowable discharge rate and sizing multiple orifices for drainage areas less than 50 acres; the SCS method is strongly recommended for areas greater than 50 acres.

(8) See Table 1 for storage requirements for orifices with equal head pressure between adjacent orifices.

(9) See Multiple Restrictor/Oil Pollution (FROP) Control Device.

(10) For multiple orifices with unequal head pressure between adjacent orifices, the Engineer must calculate the DR value as defined in "Criteria for Use of Fixed Multiple Orifices" and "Supplement to Criteria for Use of Fixed Multiple Orifices" (available at the Surface Water Management Division).

TABLE 1

STORAGE REQUIREMENTS FOR MULTIPLE ORIFICES

AREA	Type* and Number of Outlets	10-Year Design Storm		25-Year Design Storm	
		Peak Storage Time(Minutes)	Maximum Storage Volume (Cu.Ft/Ac)	Peak Storage Time(Minutes)	Maximum Storage Volume (Cu.Ft/Ac)
Seattle/ Renton	One	$T = -25+\sqrt[N]{\frac{1762}{Qo}}$	$Vs = \frac{2820T - 40QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{2138}{Qo}}$	$Vs = \frac{3420T - 40QoT}{T+25}$
Seattle/ Renton	Two	$T = -25+\sqrt[N]{\frac{70500}{29.9Qo}}$	$Vs = \frac{2820T-29.9QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{85500}{29.9Qo}}$	$Vs = \frac{3420T-29.9QoT}{T+25}$
Seattle/ Renton	Three	$T = -25+\sqrt[N]{\frac{70500}{26.4Qo}}$	$Vs = \frac{2820T-26.4QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{85500}{26.4Qo}}$	$Vs = \frac{3420T-26.4QoT}{T+25}$
Seattle/ Renton	Four	$T = -25+\sqrt[N]{\frac{70500}{25.1Qo}}$	$Vs = \frac{2820T-25.1QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{85500}{25.1Qo}}$	$Vs = \frac{3420T-25.1QoT}{T+25}$
Seattle/ Renton	Five	$T = -25+\sqrt[N]{\frac{70500}{24.1Qo}}$	$Vs = \frac{2820T-24.1QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{85500}{24.1Qo}}$	$Vs = \frac{3420T-24.1QoT}{T+25}$

* Orifices with equal head pressure between adjacent orifices.

M.Tseng/L.Gibbons/7/19/85

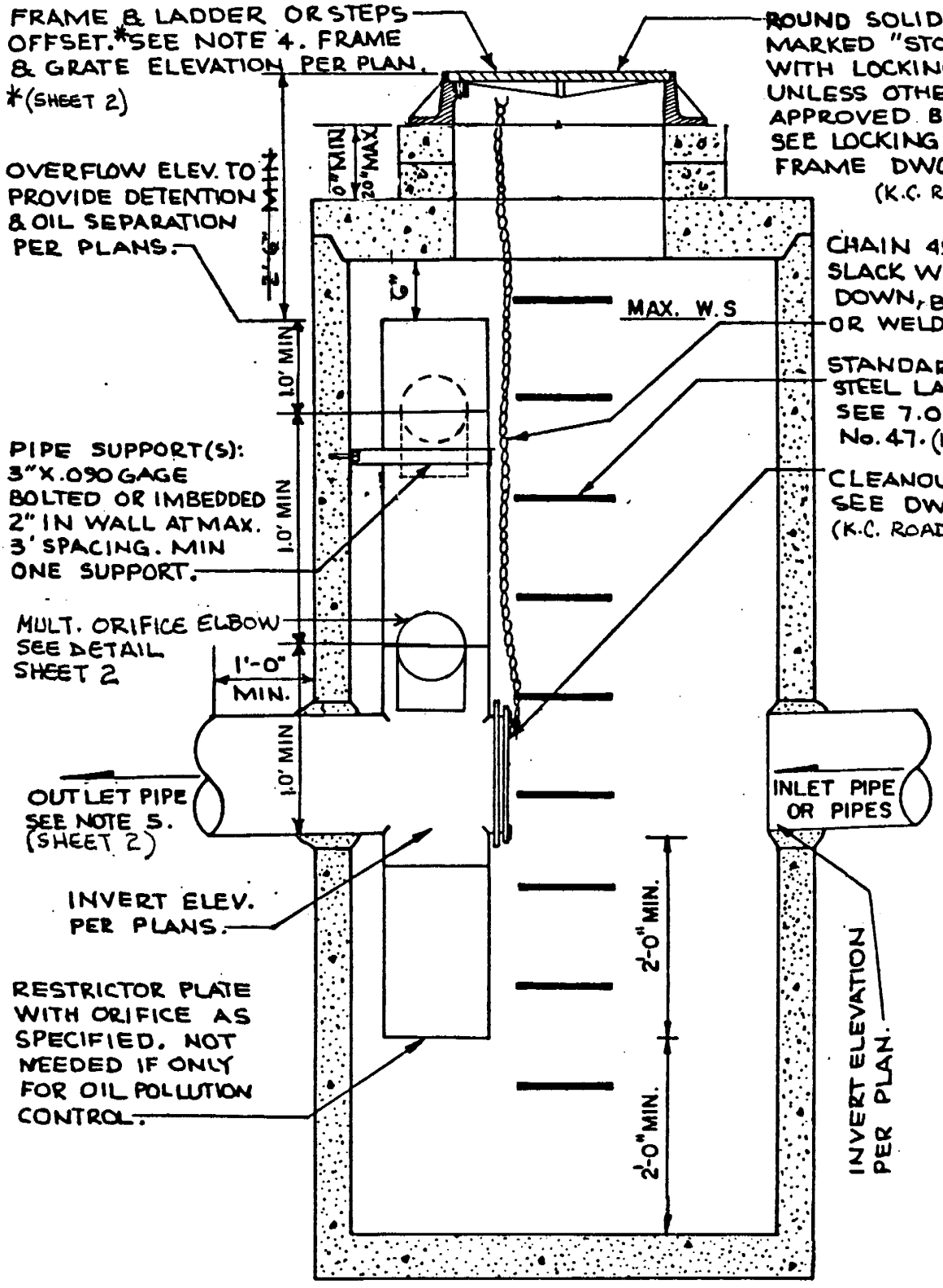
TABLE 1 (Continued)

STORAGE REQUIREMENTS FOR MULTIPLE ORIFICES

AREA	Type* and Number of Outlets	10-Year Design Storm		25-Year Design Storm	
		Peak Storage Time(Minutes)	Maximum Storage Volume (Cu.Ft/Ac)	Peak Storage Time(Minutes)	Maximum Storage Volume (Cu.Ft/Ac)
Tacoma	One	$T = -25+\sqrt[N]{\frac{1875}{Qo}}$	$Vs = \frac{3000T - 40QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{2194}{Qo}}$	$Vs = \frac{3510T - 40QoT}{T+25}$
Tacoma	Two	$T = -25+\sqrt[N]{\frac{75000}{29.9Qo}}$	$Vs = \frac{3000T-29.9QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{87750}{29.9Qo}}$	$Vs = \frac{3510T-29.9QoT}{T+25}$
Tacoma Renton	Three	$T = -25+\sqrt[N]{\frac{75000}{26.4Qo}}$	$Vs = \frac{3000T-26.4QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{87750}{26.4Qo}}$	$Vs = \frac{3510T-26.4QoT}{T+25}$
Tacoma	Four	$T = -25+\sqrt[N]{\frac{75000}{25.1Qo}}$	$Vs = \frac{3000T-25.1QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{87750}{25.1Qo}}$	$Vs = \frac{3510T-25.1QoT}{T+25}$
Tacoma	Five	$T = -25+\sqrt[N]{\frac{75000}{24.1Qo}}$	$Vs = \frac{3000T-24.1QoT}{T+25}$	$T = -25+\sqrt[N]{\frac{87750}{24.1Qo}}$	$Vs = \frac{3510T-24.1QoT}{T+25}$

* Orifices with equal head pressure between adjacent orifices.

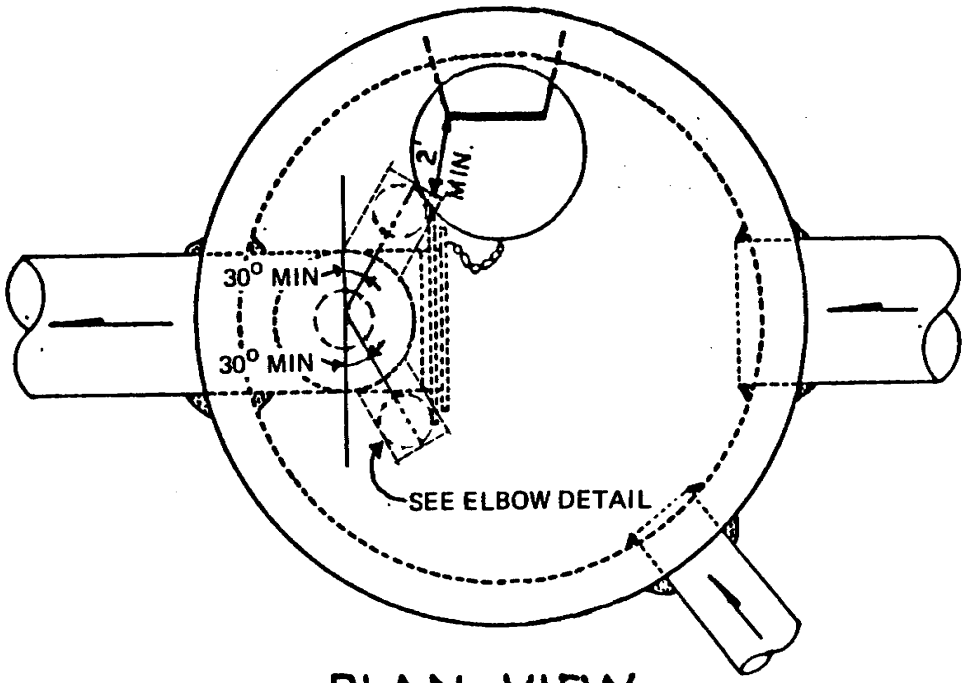
M.Tseng/L.Gibbons/7/19/85



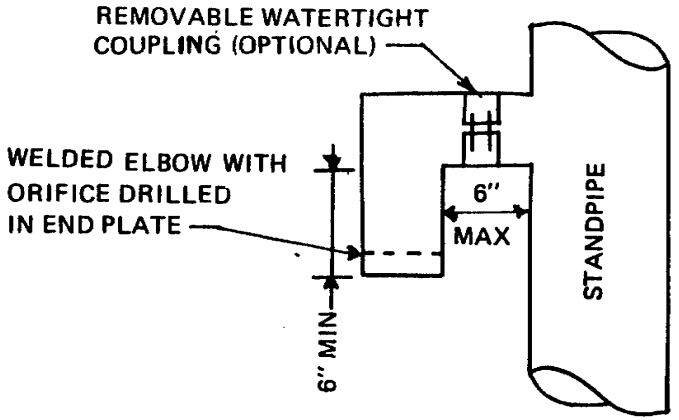
CATCH BASIN TYPE II
DIAMETER AS REQUIRED

(ENGINEER SHALL SHOW FROP DETAILS TO SCALE)

MULT. FLOW RESTRICTOR/OIL POLLUTION CONTROL DEVICE, TEE TYPE. (FROP-T) SHT. 1



PLAN VIEW



ELBOW DETAIL

NOTES:

1. PIPE SIZES AND SLOPES: PER PLANS.
2. OUTLET CAPACITY: NOT LESS THAN COMBINED INLETS.
3. METAL PARTS: CORROSION RESISTANT. GALVANIZED PIPE PARTS TO HAVE ASPHALT TREATMENT 1.
4. FRAME & LADDER OR STEPS OFFSET SO
   A. CLEANOUT GATE IS VISIBLE FROM TOP.
   B. CLIMB-DOWN SPACE IS CLEAR OF RISER AND CLEANOUT GATE.
   C. FRAME IS CLEAR OF CURB.
5. IF METAL OUTLET PIPE CONNECTS TO CEMENT CONCRETE PIPE: OUTLET PIPE TO HAVE SMOOTH O.D. EQUAL TO CONCRETE PIPE I.D. LESS 1/4".
6. MULTI ORIFICE ELBOWS MAY BE LOCATED AS SHOWN OR ENTIRELY ON ONE SIDE OF RISER ASSURING ADEQUATE LADDER ACCESS.

MULT. FLOW RESTRICTOR / OIL POLLUTION CONTROL DEVICE, TEE TYPE. (FROP-T) SHT. 2

King County Department of Public Works

Surface Water Management Division

Special Information Bulletin

Effective January 1, 1985

Subject: Critical Drainage Area Designation for the Bear-Evans Creek Drainage Basin

This bulletin announces the designation of the Bear-Evans Creek drainage basin as a critical flood, drainage and erosion area as provided by King County Code, Section 20.50.055 of the Surface Water Runoff Policy.

Reason for Decision

Analysis of existing flooding, drainage and erosion conditions in the Bear-Evans Creek drainage basin shows that the basin qualifies for designation as a critical area under existing King County Code. Flood damage and stream-bank erosion of public and private property, increased surface water runoff and reduced water quality for stream uses have occurred in the basin. Measures are needed to keep these hazards from increasing.

Affected Areas

As part of the designation program, all stream reaches in the Bear-Evans drainage basin were surveyed and assigned numerical ratings. The ratings are based on a total accumulated from eight survey parameters that evaluate the extent of stream-bank erosion and flooding and the condition of existing fish habitat. Based on individual scores, all stream reaches were then classified into three ratings: 1, 2 or 3. Reaches rated 1 or 2—the highest ratings—are good fish habitat or are especially sensitive to increases in surface water volumes, peak runoff, erosion and sedimentation. These stream reaches have been assigned special protective measures that are described in Table 1, on page 4.

Stream reaches rated 3 include areas where previous land-use changes have affected stream habitat. These reaches will be adequately protected by existing regulations for surface water runoff control as defined in King County Code 20.50. More stringent measures for stream reaches rated 3, however, are required if they are located upstream of reaches rated 1 or 2.

These rated stream reaches and corresponding drainage areas are mapped for use by developers as well as plan reviewers, inspectors and the general public (see Figure 1, page 3).

For further information, Call 344-3874

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Who is Affected and How

To protect the critical stream reaches and guard against water quality problems in the drainage basin, this critical area designation program establishes special development drainage conditions keyed to each rating as shown in Table 1, on page 4.

Effective January 1, 1985, a developer or designee must comply with Section 20.50.060 of King County Surface Water Runoff Policy, by implementing the special drainage conditions as designated in the drainage areas shown in Figure 1, on page 3.

The drainage conditions pertain to eight categories of surface water management action (Table 1, on page 4): easements, grass-line swales, detention pond design, drainage design, stream crossings, direct stream discharges, erosion/sedimentation control, facility operation and maintenance.

Benefits of Implementation

Implementation of these special drainage conditions will benefit the community in several ways. They will

- Maintain existing water quality and fish habitat, enhancing the value of streamside developments.
- Prevent existing problems from becoming more severe.
- Reduce costly stream cleanup and restoration work.
- Reduce liability for impacts on downstream properties.
- Provide a link to the community planning process.
- Provide a model for other basins.
- Avoid a no growth policy that occurs when drainage and/or erosion problems become a crisis.
- Enhance the natural surroundings of the final development, making homes more attractive to prospective buyers.

Agency Inspection

Metro and King County are implementing a two-part inspection effort to determine whether the project maintains water resources over a one-year period. King County Surface Water Management will take the lead in this effort. Metro will assist with its ongoing water quality monitoring surveys.

King County will inspect development sites in the Bear-Evans Creek Drainage Basin and establish a special drainage condition checklist for each type of development. The County will also inspect construction sites to verify that developers are implementing the special drainage conditions.

As part of its existing responsibilities, Metro will monitor the water quality of Bear-Evans Creek. Staff will survey for stream-bank erosion, unstable streambeds and muddy water. This information will help King County measure the in-stream effectiveness of the required special drainage conditions. Metro staff will also respond to water quality complaints, or trouble calls, in coordination with King County Surface Water Management.

For more information, contact King County Surface Water Management at 344-3874 or 344-4034.

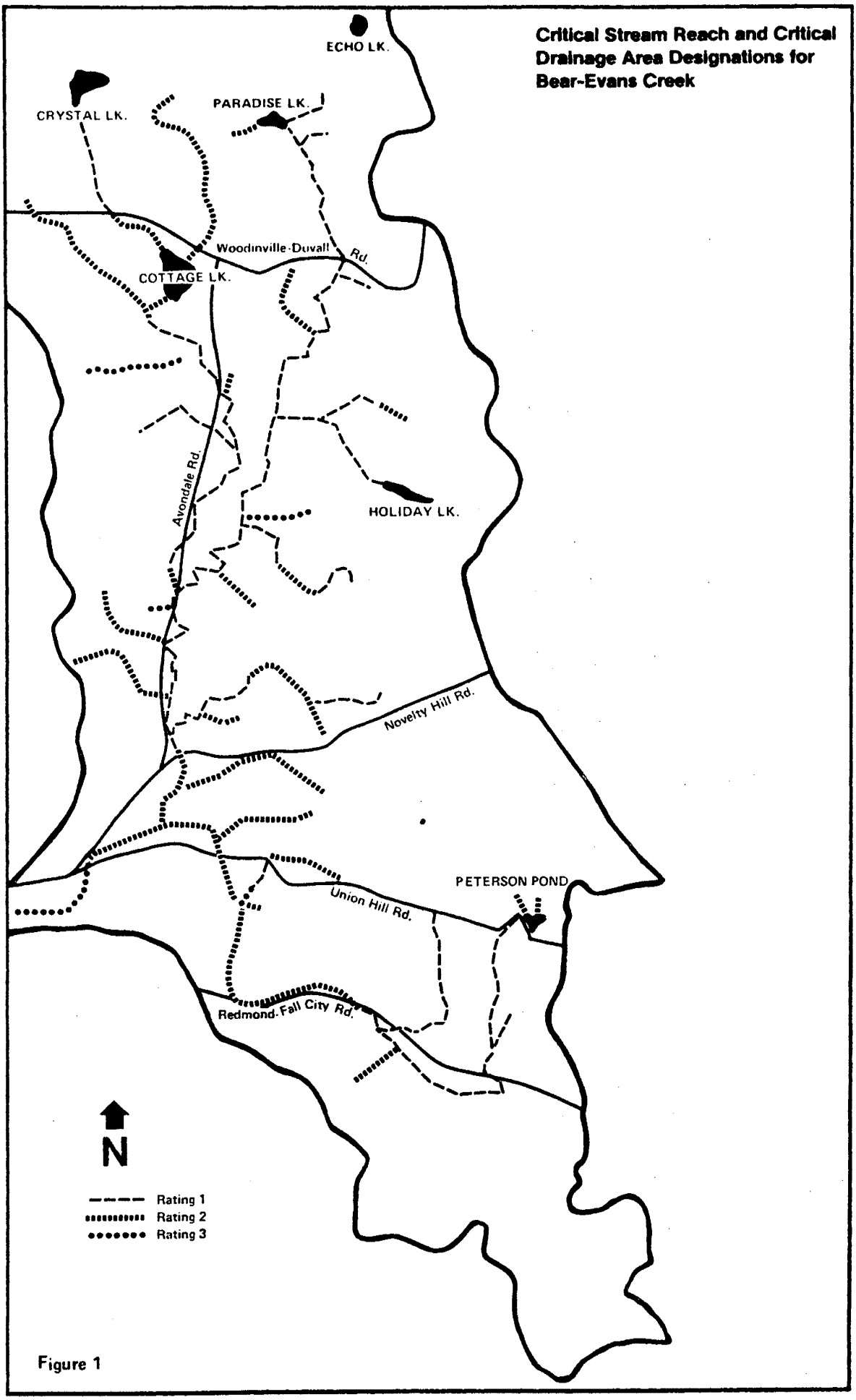
Critical Stream Reach and Critical Drainage Area Designations for Bear-Evans Creek
ECHO LK.
CRYSTAL LK.
PARADISE LK.
Woodinville-Duvall Rd.
COTTAGE LK.
Avondale Rd.
HOLIDAY LK.
Novelty Hill Rd.
PETERSON POND
Union Hill Rd.
Redmond-Fall City Rd.
N
Rating 1
Rating 2
Rating 3

Figure 1

Table 1.

Special Drainage Conditions for the Bear-Evans Basin Critical Area Designation *

Type of Action	Critical Stream Reach Rating †		
	Rating 1	**Rating 2**	**Rating 3**
1. Riparian Native Growth Easement ‡	30 feet upland from top of stream bank	20 feet upland from top of stream bank	10 feet upland from top of stream bank
2. Grass-lined swales	a. Minimum of 200 feet of grass swale either before or after detention facility. b. Incorporate grass swales where feasible throughout the development.	a. Same as Rating 1. b. Same as Rating 1.	a. Follow currently established SWM design standards. b. Follow currently established SWM design standards.
3. Detention Pond Design	a. Two-cell pond designed and constructed with fore-bay and gravel filter. b. Use wet pond—i.e. pond with continual dead storage—for areas with adequate soil for infiltration. Design pond with equal live and dead storage capacity (infiltration sites are not to be used for temporary erosion and sedimentation control). For sites with inadequate soils, investigate design and construction alternatives for an underdrain system tied to the outlet. c. Outlet designed for multiple orifice.	a. Same as Rating 1. b. Same as Rating 1 only when Rating 2 is upstream of Rating 1. Otherwise follow currently established SWM design standards. c. Same as Rating 1.	a. Follow currently established SWM design standards. b. Follow currently established SWM design standards. c. Multiple orifice used where the design storm peak is greater than 1 cfs.
4. Drainage design	All drainage facilities designed for 25-year storm and 5-year release rate unless otherwise approved by SWM. No structures, fills or obstructions shall be allowed within the 25-year floodplains or the floodway channels of 100-year floodplains unless approved by SWM.	Same as Rating 1.	Follow currently established SWM design standards.
5. Stream Crossings	Use super span (arch pipe), bridge or oversized culverts on any road or utility crossings of the stream consistent with Wash. State Hydraulics Code (administered by WDF and WDG). Avoid installation of multiple culverts.	Same as Rating 1.	Follow currently established SWM design standards.
6. Direct Discharge to Stream	a. Conduct downstream hydraulics analysis to evaluate impacts at storm-water confluence with stream (erosion/scour effects on stream habitat). b. Storm-water energy must be dissipated before reaching stream. c. Wherever feasible, design and construct on-site swale systems for discharge to the stream. d. Verify on a project by project basis that storm-sewer grates are labeled "discharge to stream."	a. Follow currently established SWM design standards. b. Same as Rating 1. c. Follow currently established SWM design standards. d. Same as Rating 1.	a. Follow currently established SWM design standards. b. Follow currently established SWM design standards. c. Follow currently established SWM design standards. d. Same as Rating 1.
7. Erosion and Sedimentation Control (ESC)	a. SWM may require the ESC facility be designed for 25-year storm and 5-year release rate. b. Timing of site stabilization is important for erosion control. For construction activity October through May, obtain written approval from an inspector from the Development Inspection Section stating that the site is adequately stabilized. c. Notify contractors of single-family residences of proper BMPs. d. Assign responsibility for ESC to one person from the private sector associated with the development. e. Reserve an area of natural vegetation and require that standby pumping supplies are available at each development site for removal of runoff sediment. f. Increase the frequency of public sector inspection of ESC facilities on the sites. Monitor performance.	a. Same as Rating 1 when Rating 2 is upstream of Rating 1, otherwise follow existing regulations. b. Same as Rating 1 when Rating 2 is upstream of Rating 1, otherwise follow timing window in Rating 3. c. Same as Rating 1. d. Same as Rating 1. e. Same as Rating 1. f. Same as Rating 1.	a. Follow currently established SWM design standards. b. Timing of site stabilization is important for erosion control. For construction activity October through March, obtain written approval from an inspector stating that the site is adequately stabilized. c. Follow currently established SWM design standards. d. Follow currently established SWM design standards. e. Follow currently established SWM design standards. f. Follow currently established SWM design standards.
8. Facility Operation and Maintenance	a. Increase the frequency of public sector inspection during tenure of the maintenance bond. b. Have the public sector monitor performance of the permanent facilities.	a. Same as Rating 1. b. Same as Rating 1.	a. Follow currently established SWM design standards. b. Follow currently established SWM design standards.

Footnotes:

(*) Must be used with critical stream reach and critical drainage area designations for Bear-Evans Creek (Figure 1.)
(†) Special drainage conditions for each stream rating (i.e. 1, 2 or 3). Apply to all development within sub-basin boundaries as shown on Figure 1.
(‡) To be considered a supplement to the King County Resources Planning Stream Corridor Project.

Retention Volume

1. The smaller the run the smaller the storage req'd